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Physics and Astronomy
Classification Scheme®—2008
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Introduction

The Physics and Astronomy Classification Scheme® (PACS®) is a hierarchical subject classification scheme designed to classify and categorize the literature of physics and astronomy. PACS provides an essential tool for classification and efficient retrieval of literature in physics and astronomy; as such, PACS is used by AIP and other international publishers of journals in physics, astronomy, and related fields.

What is PACS?

PACS contains ten broad subject categories subdivided into narrower categories. The hierarchy includes mainly four levels of depth, with the narrowest term giving the most detailed characterization. However, beginning with the 2006 edition, a fifth level hierarchy was introduced; subsequently, in this new edition, the fifth level hierarchy is continued in sections that have undergone revision and will also be a part of future editions. PACS also includes detailed appendices for acoustics and geophysics, a nanoscale science and technology supplement, and a topical alphabetical index with corresponding PACS codes.

Depending on the topic, the most detailed PACS code may be found at the third, fourth, or fifth hierarchical levels. At these three levels, each PACS code consists of six alphanumeric characters divided into three pairs. The examples, in the table below, illustrate the structure and format of PACS codes for all levels of the scheme, using PACS codes where the hierarchy terminates at the third, fourth, and fifth levels:

<table>
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</thead>
<tbody>
<tr>
<td>1st</td>
<td>00. GENERAL</td>
<td>30. ATOMIC AND MOLECULAR PHYSICS</td>
<td>90. GEOPHYSICS, ASTRONOMY, AND ASTROPHYSICS</td>
<td>Broadest category; there are 10 such codes from 00 to 90, in increments of 10</td>
</tr>
<tr>
<td>2nd</td>
<td>04. General relativity and gravitation</td>
<td>32. Atomic properties and interactions with photons</td>
<td>91. Solid Earth physics</td>
<td>More specific category; up to 9 such codes under each Level 1 category</td>
</tr>
<tr>
<td>3rd</td>
<td>04.65. Properties of atoms</td>
<td>32.10. Properties of atoms</td>
<td>91.25. Geomagnetism and paleomagnetism; geoelectricity</td>
<td>Fairly specific category; “−” or “+” as 5th character denotes presence or absence, respectively, of 4th level</td>
</tr>
<tr>
<td>4th</td>
<td>32.10. Ionization potentials, electron affinities</td>
<td>91.25. Rock and mineral magnetism</td>
<td></td>
<td>Most specific category found in most of PACS; “−” or a lowercase letter as the 6th character denotes presence or absence, respectively, of 5th level</td>
</tr>
<tr>
<td>5th</td>
<td></td>
<td>91.25.fd Environmental magnetism</td>
<td></td>
<td>Most specific category found in PACS; the 5th character is the same as for the 4th level code, but lowercase</td>
</tr>
</tbody>
</table>
Note that the use of uppercase and lowercase letters as the fifth character for fourth- and fifth-level codes, respectively, is a means to easily distinguish the level of a given code; the use of italics for the fifth-level serves a similar purpose. However, case and font are not needed to determine uniqueness, i.e., there are no redundant codes.

**How to Use PACS**

In order to classify an article, the main topics presented in that article must be identified. The most specific PACS codes that describe the content of an article are then selected using the alphabetical index to PACS. The first code is reserved for the main topic of the paper. Select as many codes as are necessary to classify the paper; three to four codes are generally sufficient. For errata or related items, an additional code must be selected from 99.10. — x **Errata and other corrections**.

**What is New in PACS 2008?**

New to the printed version of PACS is the addition of a collection of terms applicable to nanoscale science and technology, which appears as a supplement at the back of this book. Similar nanoscience supplements have been published previously only as part of the online edition of PACS.

There are extensive revisions in the following sections included in PACS 2008; these sections have been expanded with many new fourth- and fifth-level codes:

- **20** Nuclear physics
- **30** Atomic and molecular physics
- **42** Optics
- **60** Condensed matter: structural, mechanical, and thermal properties
- **87** Biological and medical physics

Minor revisions were done in the following sections:

- **03.67** Quantum information
- **04** General relativity and gravitation
- **41** Electromagnetism; electron and ion optics
- **47.60** Flow phenomena in quasi-one-dimensional systems
- **78.47** Spectroscopy of solid state dynamics
- **89.70** Information and communication theory
- **96.30** Solar system objects

The minor revisions include additions of PACS codes, modifications of the text of PACS codes, and some PACS code deletions. The 2008 PACS Special Edition (available at the below URL) contains a full listing of PACS 2008 with new, modified, and deleted codes highlighted; the Special Edition serves as a bridge between PACS 2006 and 2008.

**Online Availability**

PACS is freely accessible online (both the hierarchical scheme and the topical alphabetical index) at http://www.aip.org/pacs. It can be downloaded in HTML and ASCII formats.

**Availability of Printed PACS**

Complimentary printed copies of PACS may be obtained by contacting pacs@aip.org (Scientific Classification Department, American Institute of Physics, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502, USA).

**Community Feedback**

AIP welcomes feedback from the scientific community. Any comments or suggestions you may have, both on the scheme and on the form of presentation, may be sent to pacs@aip.org.
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American Institute of Physics (AIP) gratefully acknowledges the assistance and cooperation of the AIP Subcommittee on Classification and Information Retrieval (SCIR), consisting of appointed members representing a broad spectrum of scientific disciplines, which has oversight responsibility for PACS development. In addition, invaluable advice was provided by the members of the PACS Working Groups, and Editors of Member and Affiliated Society journals, as well as by the many advisors from the American Physical Society (APS), and by members of the physics community at large. Particular thanks are due to two long-time contributors: Stanley Brown, Editorial Director (retired) of the APS Journals, for his leadership and tireless efforts in support of PACS; and Safia Hameed, currently AIP’s Scientific Classification consultant, for providing more than three decades of expert guidance in PACS development.

Members of both AIP’s SCIR and the Working Groups formed under their charge serve on a voluntary basis. We express sincere appreciation to these dedicated individuals. Listed below are members of the AIP SCIR, Working Groups, and PACS 2008 Project Team, along with individual advisors, whose efforts were invaluable in producing this new edition of the Physics and Astronomy Classification Scheme:

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- Leslie Coates
- Maya Flikop
- Deborah Gilde
- Robert Hollowell
- Joy Jones
- Deborah McHone
- Richard O’Keeffe
- Terry Williams

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Summary of PACS 2008

00. GENERAL
01. Communication, education, history, and philosophy
02. Mathematical methods in physics
03. Quantum mechanics, field theories, and special relativity
04. General relativity and gravitation
05. Statistical physics, thermodynamics, and nonlinear dynamical systems
06. Metrology, measurements, and laboratory procedures
07. Instruments, apparatus, and components common to several branches of physics and astronomy

10. THE PHYSICS OF ELEMENTARY PARTICLES AND FIELDS
11. General theory of fields and particles
12. Specific theories and interaction models; particle systematics
13. Specific reactions and phenomenology
14. Properties of specific particles

20. NUCLEAR PHYSICS
21. Nuclear structure
23. Radioactive decay and in-beam spectroscopy
24. Nuclear reactions: general
25. Nuclear reactions: specific reactions
26. Nuclear astrophysics
27. Properties of specific nuclei listed by mass ranges
28. Nuclear engineering and nuclear power studies
29. Experimental methods and instrumentation for elementary-particle and nuclear physics

30. ATOMIC AND MOLECULAR PHYSICS
31. Electronic structure of atoms and molecules: theory
32. Atomic properties and interactions with photons
33. Molecular properties and interactions with photons
34. Atomic and molecular collision processes and interactions
36. Exotic atoms and molecules; macromolecules; clusters
37. Mechanical control of atoms, molecules, and ions

40. ELECTROMAGNETISM, OPTICS, ACOUSTICS, HEAT TRANSFER, CLASSICAL MECHANICS, AND FLUID DYNAMICS
41. Electromagnetism; electron and ion optics
42. Optics
43. Acoustics
44. Heat transfer
45. Classical mechanics of discrete systems
46. Continuum mechanics of solids
47. Fluid dynamics

50. PHYSICS OF GASES, PLASMAS, AND ELECTRIC DISCHARGES
51. Physics of gases
52. Physics of plasmas and electric discharges

60. CONDENSED MATTER: STRUCTURAL, MECHANICAL, AND THERMAL PROPERTIES
61. Structure of solids and liquids; crystallography
62. Mechanical and acoustical properties of condensed matter
63. Lattice dynamics
64. Equations of state, phase equilibria, and phase transitions
65. Thermal properties of condensed matter
66. Nonelectronic transport properties of condensed matter
67. Quantum fluids and solids
68. Surfaces and interfaces; thin films and nanosystems (structure and nonelectronic properties)

70. CONDENSED MATTER: ELECTRONIC STRUCTURE, ELECTRICAL, MAGNETIC, AND OPTICAL PROPERTIES
71. Electronic structure of bulk materials
72. Electronic transport in condensed matter
73. Electronic structure and electrical properties of surfaces, interfaces, thin films, and low-dimensional structures
74. Superconductivity
75. Magnetic properties and materials
76. Magnetic resonances and relaxations in condensed matter, Mössbauer effect
77. Dielectrics, piezoelectrics, and ferroelectrics and their properties
78. Optical properties, condensed-matter spectroscopy and other interactions of radiation and particles with condensed matter
79. Electron and ion emission by liquids and solids; impact phenomena

80. INTERDISCIPLINARY PHYSICS AND RELATED AREAS OF SCIENCE AND TECHNOLOGY
81. Materials science
82. Physical chemistry and chemical physics
83. Rheology
84. Electronics; radiowave and microwave technology; direct energy conversion and storage
85. Electronic and magnetic devices; microelectronics
87. Biological and medical physics
89. Other areas of applied and interdisciplinary physics

90. GEOPHYSICS, ASTRONOMY, AND ASTROPHYSICS
91. Solid Earth physics
92. Hydrospheric and atmospheric geophysics
93. Geophysical observations, instrumentation, and techniques
94. Physics of the ionosphere and magnetosphere
95. Fundamental astronomy and astrophysics; instrumentation, techniques, and astronomical observations
96. Solar system: planetology
97. Stars
98. Stellar systems; interstellar medium; galactic and extragalactic objects and systems; the Universe

APPENDICES
*43. Acoustics
*91–94, 96. Geophysics
Nanoscale Science and Technology Supplement

*These sections are outside the ICSTI International Classification for Physics.
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</tr>
<tr>
<td>02.70.Bf</td>
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| 03.30.+p | Special relativity |
| 03.50.–z | Classical field theories |
| 03.50.De | Classical electromagnetism, Maxwell equations (for applied classical electromagnetism, see 41.20.–g) |
| 03.50.Kk | Other special classical field theories |
| 03.65.–w | Quantum mechanics [see also 03.67.–a Quantum information; 05.30.–d Quantum statistical mechanics; 31.30.–l Relativistic and quantum electrodynamics (QED) effects in atoms, molecules, and ions in atomic physics) |
| 03.65.Ca | Formalism |
| 03.65.Db | Functional analytical methods |
| 03.65.Fd | Algebraic methods (see also 02.20.–a Group theory) |
| 03.65.Ge | Solutions of wave equations: bound states |
| 03.65.Nk | Scattering theory |
| 03.65.Pm | Relativistic wave equations |
| 03.65.Sq | Semiclassical theories and applications |
| 03.65.Ta | Foundations of quantum mechanics; measurement theory (for optical tests of quantum theory, see 42.50.Ka) |
| 03.65.Ud | Entanglement and quantum nonlocality (e.g. EPR paradox, Bell’s inequalities, GHZ states, etc.) (for entanglement production and manipulation, see 03.67.Bg; for entanglement measures, witnesses etc., see 03.67.Mn; for entanglement in Bose–Einstein condensates, see 03.75.Gg) |
| 03.65.Vf | Phases: geometric; dynamic or topological |
| 03.65.Wj | State reconstruction, quantum tomography |
| 03.65.Xp | Tunneling, traversal time, quantum Zeno dynamics |
| 03.65.Yz | Decoherence; open systems; quantum statistical methods (see also 03.67.Pp in quantum information; for decoherence in Bose–Einstein condensates, see 03.75.Gg) |
| 03.67.Dd | Quantum cryptography and communication security |
| 03.67.Hk | Quantum communication |
| 03.67.Lx | Quantum computation architectures and implementations |
| 03.67.Mn | Entanglement measures, witnesses, and other characterizations (see also 03.65.Ud Entanglement and quantum nonlocality; 42.50.Dv Quantum state engineering and measurements in quantum optics) |
| 03.67.Pp | Quantum error correction and other methods for protection against decoherence (see also 03.65.Yz Decoherence; open systems; quantum statistical methods; for decoherence in Bose–Einstein condensates, see 03.75.Gg) |
| 03.70.+k | Theory of quantized fields (see also 11.10.–z Field theory) |
| 03.75.–b | Matter waves (for atom interferometry, see 37.25.+k; see also 67.85.–d ultradense gases, trapped gases in quantum fluids and solids) |
| 03.75.Be | Atom and neutron optics |
| 03.75.Dg | Atom and neutron interferometry |
| 03.75.Gg | Entanglement and decoherence in Bose–Einstein condensates |
| 03.75.Hh | Static properties of condensates; thermodynamical, statistical, and structural properties |
| 03.75.Kk | Dynamic properties of condensates; collective and hydrodynamic excitations, superfluid flow |
| 03.75.Lm | Tunneling, Josephson effect, Bose–Einstein condensates in periodic potentials, solitons, vortices, and topological excitations |
| 03.75.Mn | Multicomponent condensates; spinor condensates |
| 03.75.Nt | Other Bose–Einstein condensation phenomena |
| 03.75.Pp | Atom lasers |
| 03.75.Ss | Degenerate Fermi gases |

4. General relativity and gravitation (for astrophysical aspects, see 95.30.Sf Relativity and gravitation; for relativistic aspects of cosmology, see 98.80.Jk) |

---

04.20.–q | Classical general relativity (see also 02.40.–k Geometry, differential geometry, and topology) |
<p>| 04.20.Cv | Fundamental problems and general formalism |
| 04.20.Dw | Singularities and cosmic censorship |
| 04.20.Ex | Initial value problem, existence and uniqueness of solutions |</p>
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**05. Statistical physics, thermodynamics, and nonlinear dynamical systems (see also 02.50.−r Probability theory, stochastic processes, and statistics)***

| 05.10.−a | Computational methods in statistical physics and nonlinear dynamics (see also 02.70.−c in mathematical methods in physics) |
| 05.10.Cc | Renormalization group methods |
| 05.10.Gg | Stochastic analysis methods (Fokker–Planck, Langevin, etc.) |
| 05.10.Nn | Monte Carlo methods (see also 02.70.Tt. Ul in mathematical methods in physics; for Monte Carlo methods extensively used in subdivisions of physics, see the appropriate section; for example, see 52.65.Pp in plasma simulation) |
| 05.20.−y | Classical statistical mechanics |
| 05.20.Dd | Kinetic theory (see also 51.10.−y Kinetic and transport theory of gases) |
| 05.20.Gg | Classical ensemble theory |
| 05.20.Jj | Statistical mechanics of classical fluids (see also 47.10.−g General theory in fluid dynamics) |
| 05.30.−d | Quantum statistical mechanics (for quantum fluids aspects, see 67.10.Fj) |
| 05.30.Ch | Quantum ensemble theory |
| 05.30.Fk | Fermion systems and electron gas (see also 71.10.−w Theories and models of many-electron systems; see also 67.10.Db Fermion degeneracy in quantum fluids) |
| 05.30.Jp | Boson systems (for static and dynamic properties of Bose–Einstein condensates, see 03.75.Hh and 03.75.Kk; see also 67.10.Ba Boson degeneracy in quantum fluids) |
| 05.30.Pr | Fractional statistics systems (anyons, etc.) |
| 05.40.−a | Fluctuation phenomena, random processes, noise, and Brownian motion (for fluctuations in superconductivity, see 74.40.+k; for statistical theory and fluctuations in nuclear reactions, see 24.60.+k; for fluctuations in plasma, see 52.25.Gj) |
| 05.40.Ca | Noise |
| 05.40.Fb | Random walks and Levy flights |
| 05.40.Jc | Brownian motion |

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**05.45.−a Nonlinear dynamics and chaos (see also section 45 Classical mechanics of discrete systems; for chaos in fluid dynamics, see 47.52.+j)**

| 05.45.Ac | Low-dimensional chaos |
| 05.45.Df | Fractals (see also 47.53.+n Fractals in fluid dynamics; 61.43.Hv Fractals; macroscopic aggregates in structure of solids) |
| 05.45.Gg | Control of chaos, applications of chaos |
| 05.45.Jn | High-dimensional chaos |
| 05.45.Mt | Quantum chaos; semiclassical methods |
| 05.45.Pq | Numerical simulations of chaotic systems |
| 05.45.Ra | Coupled map lattices |
| 05.45.Tp | Time series analysis |
| 05.45.Vx | Communication using chaos |
| 05.45.Xt | Synchronization; coupled oscillators |
| 05.45.Yv | Solitons (see 52.35.Sb for solitons in plasma; for solitons in acoustics, see 43.25.Rq—in Acoustics Appendix; see 42.50.Md, 42.65.Tg, 42.81.Dp for solitons in optics; see also 03.75.Lm in matter waves; for solitons in space plasma physics, see 94.05.Fg; for solitary waves in fluid dynamics, see 47.35.Fg) |
| 05.50.−q | Lattice theory and statistics (Ising, Potts, etc.) (see also 64.60.Cn Order–disorder transformations, and 75.10.Hk Classical spin models) |
| 05.60.−k | Transport processes |
| 05.60.Cd | Classical transport |
| 05.60.Gg | Quantum transport |
| 05.65.+b | Self-organized systems (see also 45.70.−n in classical mechanics of discrete systems) |
### Thermodynamics

(see also section 64 Equations of state, phase equilibria, and phase transitions, and section 65 Thermal properties of condensed matter; for chemical thermodynamics, see 82.60.–s; for thermodynamics of plasmas, see 52.25.Kn; for thermodynamic properties of quantum fluids, see section 67)

#### Thermodynamics of nanoparticles, see 82.60.Qr

#### Thermodynamic processes in astrophysics, see 95.30.Tg

#### Thermodynamics in volcanology, see 91.40.Pc

#### Thermodynamic functions and equations of state

(see also 51.30.+i

#### Thermodynamic properties, equations of state in physics of gases; for equations of state of specific substances, see 64.30.–t; for equations of state of nuclear matter, and of neutron-star matter, see 21.65.Mn and 26.60.Kf respectively; see also 95.30.Tg in astronomy)

#### Phase transitions: general studies

(see also 64.70.Tg Quantum phase transitions)

#### Critical point phenomena

#### Nonequilibrium and irreversible thermodynamics

(see also 82.40.Bj

#### Oscillations, chaos, and bifurcations in physical chemistry and chemical physics)

#### Interface and surface thermodynamics

(see also 68.35.Md

#### Surface thermodynamics, surface energies in surfaces and interfaces)

#### Other topics in statistical physics, thermodynamics, and nonlinear dynamical systems

(restricted to new topics in section 05)

### 06. Metrology, measurements, and laboratory procedures

(for laser applications in metrology, see 42.62.Eh)

#### Metrology

(see also 51.30.+i

#### Measurement and error theory

#### Units and standards

#### Units

#### Standards and calibration

#### Determination of fundamental constants

#### Measurements common to several branches of physics and astronomy

#### Spatial dimensions (e.g., position, lengths, volume, angles, and displacements)

#### Mass and density

#### Time and frequency

#### Velocity, acceleration, and rotation

#### Basic electromagnetic quantities

(see also 84.37.+q Measurements in electric variables)

#### Laboratory procedures

#### Sample preparation (including design of sample holders)

#### High-speed techniques (microsecond to femtosecond)

#### Testing and inspecting procedures

#### Positioning and alignment; manipulating, remote handling

#### Workshop procedures (welding, machining, lubrication, bearings, etc.)

#### Laboratory safety procedures

#### National and international laboratory facilities, see 01.52.+r

#### Other topics in metrology, measurements, and laboratory procedures (restricted to new topics in section 06)

### 07. Instruments, apparatus, and components common to several branches of physics and astronomy

(see also each subdiscipline for specialized instrumentation and techniques)

#### Computers in experimental physics

#### Computers in education, see 01.50.Hd and 01.50.Lc

#### Computational techniques, see 02.70.–c

#### Quantum computation architectures and implementations, see 03.67.Lx

#### Optical computers, see 42.79.Ta

#### Computer systems: hardware, operating systems, computer languages, and utilities

#### Control systems

#### Design of experiments

#### Data acquisition: hardware and software

#### Data analysis: algorithms and implementation; data management (for data analysis in nuclear physics, see 29.85.–c)

#### Optical spectroscopy, see 42.50.Rc

#### Image processing (see also 42.30.Va in optics; 87.57.–s Medical imaging in biological and medical physics; 95.75.Tv

#### Digitization techniques in astronomy)

#### Data presentation and visualization: algorithms and implementation

#### Computer modeling and simulation

#### Computer interfaces (for nuclear physics applications, see 29.50.+v)

#### General equipment

#### Sensors (chemical, optical, electrical, movement, gas, etc.); remote sensing

#### Display and recording equipment, oscilloscopes, TV cameras, etc.

#### Transducers

#### Servo and control equipment; robots

#### Hygrometers; hygrometry

#### Mechanical instruments and equipment

#### Micromechanical devices and systems (for micro- and nano-electromechanical systems (MEMS/NEMS), see 85.85.+j in electronic and magnetic devices; see also 87.80.Ek Mechanical and micromechanical techniques; 87.85.Ox Biomedical instrumentation and transducers including micro-electro-mechanical systems in biological and medical physics)

#### Vibration isolation

#### Balance systems, tensile machines, etc.

#### Instruments for strain, force, and torque

#### Thermal instruments and apparatus

#### Thermometers

#### Calorimeters (for calorimeters as radiation detectors, see 29.40.Vf)

#### Furnaces; heaters

#### High-temperature instrumentation; pyrometers

#### Cryogenics; refrigerators, low-temperature detectors, and other low-temperature equipment

#### Heat engines; heat pumps; heat pipes

#### Vacuum apparatus

#### Degasification, residual gas

#### Vacuum pumps

#### Vacuum gauges

#### Vacuum testing methods; leak detectors

#### Vacuum chambers, auxiliary apparatus, and materials

#### High-pressure apparatus; shock tubes; diamond anvil cells

#### Electrical and electronic instruments and components

#### Circuits and circuit components
| 07.50.Hp | Electrical noise and shielding equipment |
| 07.50.Ls | Electrometers |
| 07.50.Qx | Signal processing electronics (see also 84.40.Ua in radiowave and microwave technology; 87.85.Ng Biological signal processing in biomedical engineering) |
| 07.55.Nk | Magnetic shielding in instruments and components |
| 07.55.Jg | Magnetometers for susceptibility, magnetic moment, and magnetization measurements |
| 07.55.Nk | Magnetic shielding in instruments and components |
| 07.57.−e | Infrared, submillimeter wave, microwave and radiowave instruments and equipment (for infrared and radio telescopes, see 95.55.Cs, 95.55.Fw, and 95.55.Jz in astronomy; for biophysical spectroscopic applications, see 87.64.−t) |
| 07.57.Hm | Infrared, submillimeter wave, microwave, and radio wave sources (see also 42.72.Ai Infrared sources in optics) |
| 07.57.Kp | Bolometers; infrared, submillimeter wave, microwave, and radiowave receivers and detectors (see also 85.60.Gz Photodetectors in electronic and magnetic devices, and 95.55.Rg Photocconductors and bolometers in astronomy) |
| 07.57.Pt | Submillimeter wave, microwave and radiowave spectrometers; magnetic resonance spectrometers, auxiliary equipment, and techniques |
| 07.57.Ty | Infrared spectrometers, auxiliary equipment, and techniques |

| 07.60.−j | Optical instruments and equipment (see also 87.64.M− Optical microscopy in biological and medical physics) |
| 07.60.−g | Optical sources, see 42.72.− |
| 07.60.−e | Optical elements, devices, and systems 42.79.− |
| 07.60.−q | Optoelectronic devices 85.60.−q |
| 07.60.−p | Optical telescopes, see 95.55.Cs |
| 07.60.Dq | Photometers, radiometers, and colorimeters |
| 07.60.Fs | Polarimeters and ellipsometers |
| 07.60.Hv | Refractometers and reflectometers |
| 07.60.Ly | Interferometers |
| 07.60.Pb | Conventional optical microscopes (for near-field scanning optical microscopes, see 07.79.Fc; for x-ray microscopes, see 07.85.Tt) |
| 07.60.Rd | Visible and ultraviolet spectrometers |
| 07.60.Vg | Fiber-optic instruments (see also 42.81.−i Fiber optics) |

| 07.64.−z | Acoustic instruments and equipment (see also 43.58.−z—in acoustics) |
| 07.68.−m | Photography, photographic instruments; xerography |
| 07.75.−h | Mass spectrometers (see also 82.80.Ms, 82.80.Nj, and 82.80.Rt in physical chemistry and chemical physics) |
| 07.77.−n | Atomic, molecular, and charged-particle sources and detectors |
| 07.77.Gx | Atomic and molecular beam sources and detectors (see also 37.20.+t Atomic and molecular beam sources and technicals, in atomic and molecular physics) |
| 07.77.Ka | Charged-particle beam sources and detectors (see also 29.40.−n Radiation detectors in nuclear physics) |
| 07.78.−s | Electron, positron, and ion microscopes; electron diffraction microscopes |
| 07.79.−v | Scanning probe microscopes and components (see also 68.37.−d Microscopy of surfaces, interfaces, and thin films) |
| 07.79.Cz | Scanning tunneling microscopes |
| 07.79.Fc | Near-field scanning optical microscopes |
| 07.79.Lh | Atomic force microscopes |
| 07.79.Pk | Magnetic force microscopes |
| 07.79.Sp | Friction force microscopes |

| 07.81.+a | Electron and ion spectrometers (see also 29.30.Dn Electron spectroscopy; 29.30.Ep Charged-particle spectroscopy in nuclear physics) |
| 07.85.−m | X- and γ-ray instruments (for x- and γ-ray telescopes, see 95.55.Ka in astronomy; see also 41.50.+h X-ray beams and x-ray optics) |
| 07.85.Fv | X- and γ-ray sources, mirrors, gratings, and detectors |
| 07.85.Jy | Diffractometers |
| 07.85.Nc | X-ray and γ-ray spectrometers |
| 07.85.Qe | Synchrotron radiation instrumentation |
| 07.85.Tt | X-ray microscopes |
| 07.87.+v | Spaceborne and space research instruments, apparatus, and components (satellites, space vehicles, etc.) (for instrumentation for space plasma physics, ionosphere, and magnetosphere, see 94.80.+g; see also 95.55.−n and 95.40.+s in astronomy) |
| 07.88.+y | Instruments for environmental pollution measurements |
| 07.89.+b | Environmental effects on instruments (e.g., radiation and pollution effects) (for environmental effects on optical elements, devices, and systems, see 42.88.+h) |
| 07.90.+c | Other topics in instruments, apparatus, and components common to several branches of physics and astronomy (restricted to new topics in section 07) |
## 10. The Physics of Elementary Particles and Fields

### 11. General theory of fields and particles (see also 03.65.-w Quantum mechanics and 03.70.+k Theory of quantized fields)

#### 11.10. Field theory (for gauge field theories, see 11.15.-q)
- 11.10.Cd Axiomatic approach
- 11.10.Et Lagrangian and Hamiltonian approach
- 11.10.Gh Renormalization
- 11.10.Hi Renormalization group evolution of parameters
- 11.10.Jj Asymptotic problems and properties
- 11.10.Kk Field theories in dimensions other than four (see also 04.50.-h Higher-dimensional gravity and other theories of gravity; 04.60.Kz Lower dimensional models; minisuperspace models in general relativity and gravitation)
- 11.10.Lm Nonlinear or nonlocal theories and models (see also 11.27.+d Extended classical solutions; cosmic strings, domain walls, texture)
- 11.10.Nx Noncommutative field theory
- 11.10.St Bound and unstable states; Bethe–Salpeter equations
- 11.10.Wx Finite-temperature field theory

#### 11.15. Gauge field theories
- 11.15.Bt General properties of perturbation theory
- 11.15.Ex Spontaneous breaking of gauge symmetries
- 11.15.Ha Lattice gauge theory (see also 12.38.Gc Lattice QCD calculations)
- 11.15.Kc Classical and semiclassical techniques
- 11.15.Me Strong-coupling expansions
- 11.15.Pg Expansions for large numbers of components (e.g., 1/N_c expansions)
- 11.15.Tk Other nonperturbative techniques

#### 11.25. Strings and branes (for cosmic strings, see 98.80.Cq in cosmology; see also 11.27.+d Extended classical solutions; cosmic strings, domain walls, texture)
- 11.25.Bb Properties of perturbation theory
- 11.25.Hf Conformal field theory, algebraic structures
- 11.25.Mj Compactification and four-dimensional models
- 11.25.Pn Noncritical string theory
- 11.25.Sq Nonperturbative techniques; string field theory
- 11.25.Tq Gauge/string duality
- 11.25.Uv D branes

### 12. Specific theories and interaction models; particle systematics

#### 12.10. Unified field theories and models (see also 04.50.-h Higher-dimensional gravity and other theories of gravity—general relativity and gravitation, 11.25.Mf Compactification and four-dimensional models)
- 12.10.Dm Unified theories and models of strong and electroweak interactions
- 12.10.Kt Unification of couplings; mass relations

#### 12.15. Electroweak interactions
- 12.15.Fr Quark and lepton masses and mixing (see also 14.60.Pq Neutrino mass and mixing)
- 12.15.Hh Determination of Kobayashi–Maskawa matrix elements
- 12.15.Ji Applications of electroweak models to specific processes
- 12.15.Lk Electroweak radiative corrections (see also 13.40.Ks Electromagnetic corrections to strong- and weak-interaction processes)
- 12.15.Mm Neutral currents

#### 12.20. Quantum electrodynamics
- 12.20.Ds Specific calculations
- 12.20.Fv Experimental tests (for optical tests in quantum electrodynamics, see 42.50.Xa)

#### 12.38. Quantum chromodynamics
- 12.38.Tt Quarks, gluons, and QCD in nuclear reactions, see 24.85.+p
- 12.38.Aw General properties of QCD (dynamics, confinement, etc.)
- 12.38.Bx Perturbative calculations
- 12.38.Cy Summation of perturbation theory
- 12.38.Gc Lattice QCD calculations (see also 11.15.Ha Lattice gauge theory)
- 12.38.Lg Other nonperturbative calculations
- 12.38.Mh Quark–gluon plasma (see also 25.75.Ng Quark deconfinement, quark–gluon plasma production and phase transitions in relativistic heavy ion collisions; see also 21.65.Qr Quark matter)
- 12.38.Qk Experimental tests

#### 12.39. Phenomenological quark models
- 12.39.Ba Bag model
- 12.39.Dc Skyrmions
- 12.39.Fe Chiral Lagrangians
- 12.39.Hg Heavy quark effective theory
- 12.39.Jh Nonrelativistic quark model
- 12.39.Ki Relativistic quark model
13. Decisions on specific reactions and phenomenology

13.15.\textit{g} Neutrino interactions
13.20.\textit{v} Leptonic, semileptonic, and radiative decays of mesons
13.20.Cz Decays of $\pi$ mesons
13.20.Eb Decays of $K$ mesons
13.20.Fc Decays of charmed mesons
13.20.Gd Decays of $J/\psi$, $\chi$, and other quarkonia
13.20.He Decays of bottom mesons
13.20.Jf Decays of other mesons
13.25.\textit{k} Hadronic decays of mesons
13.25.Cq Decays of $\pi$ mesons
13.25.Es Decays of $K$ mesons
13.25.Ft Decays of charmed mesons
13.25.Gv Decays of $J/\psi$, $\chi$, and other quarkonia
13.25.Hw Decays of bottom mesons
13.25.Js Decays of other mesons
13.30.\textit{a} Decays of baryons
13.30.Ce Leptonic, semileptonic, and radiative decays
13.30.Eg Hadronic decays
13.35.\textit{r} Decays of leptons
13.35.Bv Decays of muons
13.35.Dx Decays of taus
13.35.Hb Decays of heavy neutrinos
13.38.\textit{b} Decays of intermediate bosons
13.38.Be Decays of $W$ bosons
13.38.Dg Decays of $Z$ bosons
13.40.\textit{f} Electromagnetic processes and properties
13.40.Dk Electromagnetic mass differences
13.40.Em Electric and magnetic moments
13.40.Gp Electromagnetic form factors
13.40.Hq Electromagnetic decays
13.40.Ks Electromagnetic corrections to strong- and weak-interaction processes
13.60.\textit{r} Photon and charged-lepton interactions with hadrons (for neutrino interactions, see 13.15.\textit{g})
13.60.Fz Elastic and Compton scattering
13.60.Hb Total and inclusive cross sections (including deep-inelastic processes)
13.60.Le Meson production
13.60.Rj Baryon production
13.60.St Non-standard-model neutrinos, including right-handed neutrinos, etc.
13.66.\textit{a} Lepton-lepton interactions
13.66.Bc Hadron production in $\nu \bar{\nu}$ interactions
13.66.De Lepton production in $e^+e^-$ interactions
13.66.Fg Gauge and Higgs boson production in $e^+e^-$ interactions
13.66.Hk Production of non-standard model particles in $e^+e^-$ interactions
13.66.Jn Precision measurements in $e^+e^-$ interactions
13.66.Lm Processes in other lepton-lepton interactions
13.75.\textit{n} Hadron-induced low- and intermediate-energy reactions and scattering (energy $\leq 10$ GeV) (for higher energies, see 13.85.\textit{t})
13.75.Cs Nucleon–nucleon interactions (including antinucleons, deuteron, etc.) (for N–N interactions in nuclei, see 20, \textit{a})
13.75.Ev Hyperon–nucleon interactions
13.75.Gx Pion–baryon interactions
13.75.Jz Kaon–baryon interactions
13.75.Lb Meson–meson interactions
13.85.\textit{t} Hadron-induced high- and super-high-energy interactions (energy $> 10$ GeV) (for low energies, see 13.75.\textit{n})
13.85.Dz Elastic scattering
13.85.Fb Inelastic scattering: two-particle final states
13.85.Hd Inelastic scattering: many-particle final states
13.85.Lg Total cross sections
13.85.Ni Inclusive production with identified hadrons
13.85.Qk Inclusive production with identified leptons, photons, or other nonhadronic particles
13.85.Rm Limits on production of particles
13.85.Tp Cosmic-ray interactions (see also 96.50.S – Cosmic rays in interplanetary physics)
13.87.\textit{a} Jets in large-$Q^2$ scattering
13.87.Ce Production
13.87.Fh Fragmentation into hadrons
13.88.\textit{e} Polarization in interactions and scattering
13.90.\textit{i} Other topics in specific reactions and phenomenology of elementary particles (restricted to new topics in section 13)

14. Properties of specific particles

14.20.\textit{c} Baryons (including antiparticles)
14.20.Dh Protons and neutrons
14.20.Gk Baryon resonances with $S=0$
14.20.Jn Hyperons
14.20.Lq Charmed baryons
14.20.Mr Bottom baryons
14.20.Pt Dibaryons
14.40.\textit{n} Mesons
14.40.Aq $\pi$, $K$, and $\eta$ mesons
14.40.Cs Other mesons with $S=C=0$, mass $< 2.5$ GeV
14.40.Ev Other strange mesons
14.40.Gx Mesons with $S=C=B=0$, mass $> 2.5$ GeV (including quarkonia)
14.40.Lb Charmed mesons
14.40.Nd Bottom mesons
14.60.\textit{z} Leptons
14.60.Cd Electrons (including positrons)
14.60.Ef Muons
14.60.Fg Taus
14.60.Hi Other charged heavy leptons
14.60.Lm Ordinary neutrinos ($\nu$, $\bar{\nu}$)
14.60.Pq Neutrino mass and mixing (see also 12.15.\textit{f} Quark and lepton masses and mixing)
14.60.St Non-standard-model neutrinos, right-handed neutrinos, etc.
14.65.\textit{q} Quarks
14.65.Bt Light quarks
14.65.Dw Charmed quarks
14.65.Ey Bottom quarks
14.65.Ha Top quarks
14.70.\textit{e} Gauge bosons
14.70.Bh Photons
14.70.Dj Gluons
14.70.Fm $W$ bosons
14.70.Hp $Z$ bosons
14.70.Pw Other gauge bosons
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### 20. Nuclear Physics

#### 21. Nuclear structure

- **21.65.Mn** Equations of state of nuclear matter
- **21.65.Jk** Mesons in nuclear matter
- **21.65.Ef** Symmetry energy
- **21.65.Cd** Asymmetric matter, neutron matter

#### 21.60.Ka Monte Carlo models

- **21.60.Jz** Nuclear Density Functional Theory
- **21.60.Fw** Models based on group theory
- **21.60.Ev** Collective models

#### 21.45.Ff Three-nucleon forces

#### 21.30.Fe Forces in hadronic systems and nuclear forces

- **21.30.Cb** Nuclear forces in vacuum
- **21.30.Fe** Forces in hadronic systems and effective interactions

#### 21.85.+d Mesic nuclei

- **21.90.+f** Other topics in nuclear structure (restricted to new topics in section 21)

#### 21.80.+a Hypernuclei

- **21.70.+s** Polarization phenomena in reactions

#### 21.10.Jx Spectroscopic factors and asymptotic normalization coefficients

- **21.10.Gv** Nucleon distributions and halo features
- **21.10.Dr** Binding energies and masses

#### 21.45.−g Electromagnetic transitions

- **21.10.Ky** Electromagnetic moments
- **21.10.Ma** Level density

#### 21.30.+s Nuclear forces (see also 13.75.Cs Nuclear–nucleon interactions)

- **21.30.Cb** Nuclear forces in vacuum
- **21.30.Fe** Forces in hadronic systems and effective interactions

#### 24. Nuclear reactions: general

- **24.10.Nz** Hydrodynamic models
- **24.10.Pa** Thermal and statistical models

#### 24.80.+y Nuclear tests of fundamental interactions and symmetries

- **24.90.+d** Other topics in nuclear reactions: general (restricted to new topics in section 24)

#### 24.30.−v Resonance reactions

- **24.30.Cz** Giant resonances
- **24.30.Gd** Other resonances

#### 24.60.−k Statistical theory and fluctuations

- **24.60.Dr** Statistical compound-nucleus reactions
- **24.60.Gv** Statistical multistep direct reactions

#### 24.70. + s Surrogate reactions

- **24.75.+i** General properties of fission

#### 24.85.+p Quarks, gluons, and QCD in nuclear reactions

#### 25. Nuclear reactions: specific reactions

- **25.10.+s** Nuclear reactions involving few-nucleon systems
- **25.20.−x** Photonuclear reactions
- **25.20.Dc** Photon absorption and scattering
- **25.20.Lj** Photoproduction reactions

#### 25.30.+c Lepton-induced reactions

- **25.30.Bf** Elastic electron scattering
- **25.30.Dh** Inelastic electron scattering to specific states
- **25.30.Fj** Inelastic electron scattering to continuum

#### 25.40.−h Neutron-induced reactions (see also 28.20.−v Neutron physics)

- **25.40.Cm** Elastic proton scattering
- **25.40.Dn** Elastic neutron scattering
- **25.40.Ep** Inelastic proton scattering
- **25.40.Fq** Inelastic neutron scattering
- **25.40.Hs** Transfer reactions
- **25.40.Kv** Charge-exchange reactions
- **25.40.Lw** Radiative capture
- **25.40.Ny** Resonance reactions
25.40.Qa $(p, \pi)$ reactions
25.40.Sc Spallation reactions
25.40.Ve Other reactions above meson production thresholds (energies $> 400$ MeV)

25.43.+t Antiproton-induced reactions
25.45.−z $^2$H-induced reactions
25.45.De Elastic and inelastic scattering
25.45.Hi Transfer reactions
25.45.Kk Charge-exchange reactions

25.55.−e $^3$H, $^3$He, and $^4$He-induced reactions
25.55.Ci Elastic and inelastic scattering
25.55.Hp Transfer reactions
25.55.Kr Charge-exchange reactions

25.60.−t Reactions induced by unstable nuclei
25.60.Bx Elastic scattering
25.60.Dz Interaction and reaction cross sections
25.60.Gc Breakup and momentum distributions
25.60.Jg Resonance production in relativistic heavy-ion collisions

27. Properties of specific nuclei listed by mass ranges (an additional heading must be chosen with these entries, where the given mass number limits are, to some degree, arbitrary)

27.10.+h $A \leq 5$
27.20.+n $6 \leq A \leq 19$
27.30.+t $20 \leq A \leq 38$
27.40.+z $39 \leq A \leq 58$
27.50.+e $59 \leq A \leq 89$
27.60.+j $90 \leq A \leq 149$
27.70.+q $150 \leq A \leq 189$
27.80.+w $190 \leq A \leq 219$
27.90.+b $A \geq 220$

28. Nuclear engineering and nuclear power studies

28.20.−v Neutron physics (see also 25.40.−h Nucleon-induced reactions and 25.85.Ec Neutron-induced fission)
28.20.Cz Neutron scattering
28.20.Fc Neutron absorption
28.20.Gd Neutron transport: diffusion and moderation
28.20.Ka Thermal neutron cross sections
28.20.Np Neutron capture γ-rays

28.41.+i Fission reactors (see also 89.30.Gg nuclear fission power in energy resources)
28.41.Ak Theory, design, and computerized simulation
28.41.Bm Fuel elements, preparation, reloading, and reprocessing
28.41.Fr Reactor coolants, reactor cooling, and heat recovery
28.41.Kw Radioactive wastes, waste disposal
28.41.My Reactor control systems
28.41.Pa Moderators
28.41.Qb Structural and shielding materials
28.41.Rc Instrumentation
### 28.41 Protection systems, safety, radiation monitoring, accidents, and dismantling

- **28.41.Te** Fuel cycles
- **28.41.Vx** Fission reactor types
- **28.50.–k** Nuclear explosions (see also 47.40.–x Compressible flows; shock waves; for radiation protection from fallout, for dosimetry and exposure assessment, see 87.53.Bn; for nuclear explosion seismology, see 91.30.Rz)

### 28.50 Fuel cycles

- **28.50.Dr** Research reactors
- **28.50.Ft** Fast and breeder reactors
- **28.50.Hw** Power and production reactors
- **28.50.Ky** Propulsion reactors
- **28.50.Ma** Auxiliary generators

### 28.52 Fusion reactors

- **28.52.Av** Theory, design, and computerized simulation
- **28.52.Cx** Fueling, heating and ignition
- **28.52.Fa** Materials
- **28.52.Lf** Components and instrumentation
- **28.52.Nh** Safety

### 28.60 Isotope separation and enrichment

- **28.60.+s** Isotope separation and enrichment
- **28.65.+a** Accelerator-driven transmutation of nuclear waste

### 28.70 Nuclear explosions

- **28.70.+y** Nuclear explosions (see also 47.40.–x Compressible flows; shock waves; for radiation protection from fallout, for dosimetry and exposure assessment, see 87.53.Bn; for nuclear explosion seismology, see 91.30.Rz)

### 28.90 Other topics in nuclear engineering and nuclear power studies (restricted to new topics in section 28)

### 29. Experimental methods and instrumentation for elementary-particle and nuclear physics

#### 29.20 Accelerators (for accelerators used in medical applications, see 87.56.bd)

- **29.20.Ba** Electrostatic accelerators
- **29.20.Dr** Cyclic accelerators and storage rings
- **29.20.db** Storage rings and colliders
- **29.20.df** Betatrons
- **29.20.dk** Cyclotrons
- **29.20.dg** Synchronrons
- **29.20.Ej** Linear accelerators

#### 29.25 Particle sources and targets

- **29.25.Bx** Electron sources
- **29.25.Dz** Neutron sources
- **29.25.Lg** Ion sources: polarized
- **29.25.Ni** Ion sources: positive and negative
- **29.25.Pj** Polarized and other targets
- **29.25.Rm** Sources of radioactive nuclei

#### 29.27 Beams in particle accelerators

- **29.27.Ac** Beam injection and extraction
- **29.27.Bd** Beam dynamics; collective effects and instabilities
- **29.27.Eg** Beam handling; beam transport
- **29.27.Fh** Beam characteristics
- **29.27.Hj** Polarized beams

#### 29.30 Spectrometers and spectroscopic techniques

- **29.30.Aj** Charged-particle spectrometers: electric and magnetic

#### 29.38 Radioactive beams

- **29.38.Cs** Gas-filled counters: ionization chambers, proportional, and avalanche counters
- **29.38.Gx** Tracking and position-sensitive detectors
- **29.38.Ka** Cherenkov detectors
- **29.38.Mc** Scintillation detectors
- **29.38.Rg** Nuclear emulsions
- **29.38.Vj** Calorimeters
- **29.38.Wk** Solid-state detectors

#### 29.40 Radiation detectors

- **29.40.Ca** Data acquisition and sorting
- **29.40.Dj** Data analysis

#### 29.50 Computer interfaces

- **29.50.+v** Computer interfaces

#### 29.85 Digital computer data analysis

- **29.85.+g** Nuclear data compilation

#### 29.90 Other topics in elementary-particle and nuclear physics experimental methods and instrumentation (restricted to new topics in section 29)
30. ATOMIC AND MOLECULAR PHYSICS

31. Electronic structure of atoms and molecules: theory

31.10. +z Theory of electronic structure, electronic transitions, and chemical binding (for theory and mathematical methods applied to electronic structure of biomolecules, see 87.10. – e)

31.15. – p Calculations and mathematical techniques in atomic and molecular physics (see also 02.70. – c Computational techniques, in mathematical methods in physics)

31.15. A– Ab initio calculations
31.15. ac High-precision calculations for few-electron (or few-body) atomic systems
31.15. ae Electronic structure and bonding characteristics
31.15. ag Excitation energies and lifetimes; oscillator strengths
31.15. aj Relativistic corrections, spin-orbit effects; fine structure; hyperfine structure
31.15. am Relativistic configuration interaction (CI) and many-body perturbation calculations
31.15. ap Polarizabilities and other atomic and molecular properties
31.15. ar Strongly correlated electron systems: generalized tight-binding method
31.15. at Molecular transport characteristics; molecular dynamics; electronic structure of polymers
31.15. B– Approximate calculations
31.15. bt Statistical model calculations (including Thomas–Fermi and Thomas–Fermi–Dirac models)
31.15. bu Semi-empirical and empirical calculations (differential overlap, Hückel, PPP methods, etc.)
31.15. bv Coupled-cluster theory
31.15. E– Density-functional theory
31.15. ec Hohenberg-Kohn theorem and formal mathematical properties, completeness theorems
31.15. ee Time-dependent density functional theory
31.15. eg Exchange-correlation functionals (in current density functional theory)
31.15. ej Spin-density functionals
31.15. em Corrections for core-spin polarization, surface effects, etc.
31.15. ep Variational particle-number approach

31.15. es Applications of density-functional theory (e.g., to electronic structure and stability; defect formation; dielectric properties, susceptibilities; viscoelastic coefficients; Rydberg transition frequencies)

31.15. V– Electron correlation calculations for atoms, ions and molecules
31.15. ve Electron correlation calculations for atoms and ions: ground state
31.15. vj Electron correlation calculations for atoms and ions: excited states
31.15. vn Electron correlation calculations for diatomic molecules
31.15. vq Electron correlation calculations for polyatomic molecules
31.15. X– Alternative approaches
31.15. xf Finite-difference schemes
31.15. xg Semiclassical methods
31.15. xh Group-theoretical methods (see also 02.20. – a Group theory in mathematical methods in physics)
31.15. xj Hyperspherical methods
31.15. xk Path-integral methods
31.15. xm Quasiparticle methods
31.15. xp Perturbation theory
31.15. xr Self-consistent-field methods
31.15. xt Variational techniques
31.15. xv Molecular dynamics and other numerical methods (for simulation techniques for biomolecules, see 87.15. ak, ap)
31.15. xw Valence bond calculations

31.30. – i Corrections to electronic structure (see also 03.30. + p Special relativity; for exotic atoms and molecules, see 36.10. – k; for applications of density-functional theory, see 31.15. es)

31.30. Gs Hyperfine interactions and isotope effects (see also 32.10. Fh Fine and hyperfine structure)

31.30. – J– Relativistic and quantum electrodynamical (QED) effects in atoms, molecules, and ions
31.30. jc Relativistic corrections to atomic structure and properties
31.30. jd Relativistic corrections due to negative-energy states or processes
31.30.jf QED calculations of level energies, transition frequencies, fine structure intervals (radiative corrections; self-energy, vacuum polarization, etc.)
31.30. jg QED corrections to parity nonconserving transition amplitudes and CP violations

31.30. jh QED corrections to long-range and weak interactions
31.30. jn QED corrections to electric dipole moments and other atomic properties
31.30. jp Electron electric dipole moment
31.30. jr QED corrections (Lamb shift) in muonic hydrogen and deuterium (see also 36.10. Ee Muonium, muonic atoms and molecules)
31.30. js Corrections to bound-electron g factor
31.30. jx Nonrelativistic limits of Dirac-Fock calculations
31.30. jy Higher-order effective Hamiltonians
31.30. jz Decay rates of hydrogen-antihydrogen quasimolecules (for exotic atoms and molecules, see 36.10. – k)

31.50. – x Potential energy surfaces (for potential energy surfaces for chemical reactions, see 82.20. Kh; for collisions, see 34.20. – b)
31.50. Bc Potential energy surfaces for ground electronic states
31.50. Df Potential energy surfaces for excited electronic states
31.50. Gh Surface crossings, non-adiabatic couplings

31.70. – f Effects of atomic and molecular interactions on electronic structure (see also section 34 Atomic and molecular collision processes and interactions)
31.70. Dk Environmental and solvent effects
31.70. Hq Time-dependent phenomena: excitation and relaxation processes, and reaction rates (for chemical kinetics aspects, see 82.20. Rp)
31.70. Ks Molecular solids

31.90. + s Other topics in the theory of the electronic structure of atoms and molecules (restricted to new topics in section 31)

32. Atomic properties and interactions with photons (for quantum chaos, see 05.45. Mt; for standards of calibration, see 06.20. Fb; for relativistic and quantum electrodynamical effects, see 31.30. J –)

32.10. – f Properties of atoms (for astrophysical applications, see 95.30. Kj)
32.10. Bi Atomic masses, mass spectra,
32.10.Dk Electric and magnetic moments, polarizabilities
32.10.Ee Magnetic bound states, magnetic trapping of Rydberg states
32.10.Fn Fine and hyperfine structure (see also 31.30.Gs Hyperfine interactions and isotope effects)
32.10.Hq Ionization potentials, electron affinities
32.30.Rj X-ray spectra
32.30.Tp Vibrational analysis
32.30.Sn Rotational analysis
32.30.Rm X-ray spectra
32.40.+i Zeeman and Stark effects
32.40.+d Fluorescence, phosphorescence (including quenching)
32.50.+a Other topics in atomic properties and interactions of atoms with photons (restricted to new topics in section 32)
32.80.Xs Level crossing and optical pumping
32.80.Zb Autoionization
32.90.+a Other topics in atomic properties and interactions of atoms with photons (restricted to new topics in section 32)

33. Molecular properties and interactions with photons
33.15.−e Properties of molecules (see also section 31; Electronic structure of atoms and molecules: theory; for molecules of interest in astrophysics, see 95.30.Ky; for structure and properties of biomolecules, see 87.15.−v)
33.15.Bh General molecular conformation and symmetry; stereochemistry
33.15.Dj Interatomic distances and angles
33.15.Fm Bond strengths, dissociation energies
33.15.Hp Barrier heights (internal rotation, inversion, rotational isomerism, conformational dynamics)
33.15.Kr Electric and magnetic moments (and derivatives), polarizability, and magnetic susceptibility
33.15.Mt Rotation, vibration, and vibration–rotation constants
33.15.Pw Fine and hyperfine structure
33.15.Ry Ionization potentials, electron affinities, molecular core binding energy
33.15.Ta Mass spectra
33.15.Vb Correlation times in molecular dynamics
33.20.−t Molecular spectra (see also 78.47.J− Ultrafast pump/probe spectroscopy in condensed matter and 82.53.Kp Coherent spectroscopy of atoms and molecules in physical chemistry and chemical physics)
33.20.Bx Radio-frequency and microwave spectra
33.20.Ea Infrared spectra
33.20.Fb Raman and Rayleigh spectra (including optical scattering)
33.20.Kf Visible spectra
33.20.Lg Ultraviolet spectra
33.20.Ni Vacuum ultraviolet spectra
33.20.Rm X-ray spectra
33.20.Sn Rotational analysis
33.20.Tp Vibrational analysis
33.20.Vq Vibration–rotation analysis
33.20.Wr Vibronic, rovibronic, and rotation–electron–spin interactions
33.25.+k Nuclear resonance and relaxation (see also 76.60.−k Nuclear magnetic resonance and relaxation in condensed matter; 82.56.−b Nuclear magnetic relaxation in physical chemistry and chemical physics; 87.80.Lg Magnetic and paramagnetic resonance in biological physics)
33.35.+r Electron resonance and relaxation (see also 76.30.−v Electron paramagnetic resonance and relaxation in condensed matter)
33.40.+f Multiple resonances (including double and higher-order resonance processes, such as double nuclear magnetic resonance, electron double resonance, and microwave optical double resonance) (see also 76.70.−s Magnetic double resonances and cross effects in condensed matter)
33.45.+x Mössbauer spectra (see also 76.80.−y Mössbauer effect; other γ-ray spectroscopy in condensed matter; for biophysical applications, see 87.64.Kx; for chemical analysis applications, see 82.80.Ej)
33.50.−j Fluorescence and phosphorescence; radiationless transitions, quenching (intersystem crossing, internal conversion) (for energy transfer, see also section 34; for biophysical applications, see 87.64.Kx)
33.50.Dq Fluorescence and phosphorescence spectra
33.50.Hv Radiationless transitions, quenching
33.55.+b Optical activity and dichroism
33.57.+c Magneto- and electro-optical spectra and effects
33.60.+q Photoelectron spectra (for biophysical applications, see 87.64.Kx)
33.70.−w Intensities and shapes of molecular spectral lines and bands
33.70.Ca Oscillator and band strengths, lifetimes, transition moments, and Franck–Condon factors
33.70.Fd Absolute and relative line and band intensities
33.70.Jg Line and band widths, shapes, and shifts
33.80.—b Photon interactions with

abundances, and isotopes (for mass spectroscopy, see 07.75.+h in instruments, and 82.80.Ms, Nj, Rt in physical chemistry and chemical physics)
34. Atomic and molecular collision processes and interactions (for atomic, molecular, and ionic collisions in plasma, see 52.20.Hv; for atoms and molecules of astrophysical interest, see 95.30.Dr, Fr; see also 98.38.Bn and 98.58.Bc in interstellar media in astronomy; 87.15.K – Molecular interactions, membrane-protein interactions in biological physics)

34.10. –x General theories and models of atomic and molecular collisions and interactions (including statistical theories, transition state, stochastic and trajectory models, etc.)

34.20. –b Interatomic and intermolecular potentials and forces, potential energy surfaces for collisions (see also 82.20.Kh Potential energy surfaces for reactions; for potential energy surfaces in electronic structure calculations, see 31.50. –x)

34.20.Cf Interatomic potentials and forces

34.20.Gj Intermolecular potentials and forces

34.35. +a Interactions of atoms and molecules with surfaces

34.50. –s Scattering of atoms and molecules

34.50.Bw Energy loss and stopping power

34.50.Cx Elastic; ultracold collisions

34.50.Ez Rotational and vibrational energy transfer

34.50.Fa Electronic excitation and ionization of atoms (including beam-foil excitation and ionization)

34.50.Gb Electronic excitation and ionization of molecules

34.50.Lf Chemical reactions

34.50.Rk Laser-modified scattering and reactions

34.70. + e Charge transfer (for charge transfer in biological systems, see 82.39.Jn in physical chemistry)

34.80. –i Electron and positron scattering

34.80.Bm Elastic scattering

34.80.Dp Atomic excitation and ionization

34.80.Gs Molecular excitation and ionization

34.80.Ht Dissociation and dissociative attachment

34.80.Lx Recombination, attachment, and positronium formation

34.80.Nz Spin dependence of cross sections; polarized beam experiments

34.80.Pa Coherence and correlation

34.80.Qb Laser-modified scattering

34.80.Uv Positron scattering

34.90. +q Other topics in atomic and molecular collision processes and interactions (restricted to new topics in section 34)

36. Exotic atoms and molecules; macromolecules; clusters

36.10. –k Exotic atoms and molecules (containing mesons, antiprotons and other unusual particles)

36.10.Dr Positronium (see also 82.30.Gg Positronium chemistry)

36.10.Ee Muonium, muonic atoms and molecules (see also 31.30.jr QED corrections (Lamb shift) in muonic hydrogen and deuterium)

36.10.Gv Mesonic, hyperonic and antiprotonic atoms and molecules

36.20. –r Macromolecules and polymer molecules

36.20.Cw Molecular weights, dispersity

36.20.Ey Conformation (statistics and dynamics)

36.20.Fz Constitution (chains and sequences)

36.20.Hb Configuration (bonds, dimensions)

36.20.Kd Electronic structure and spectra

36.20.Ng Vibrational and rotational structure, infrared and Raman spectra

36.40. –c Atomic and molecular clusters (see also 61.46. –w Nanoscale materials in condensed matter)

36.40.Cg Electronic and magnetic properties of clusters

36.40.Ei Phase transitions in clusters

36.40.Gk Plasma and collective effects in clusters

36.40.Jn Reactivity of clusters

36.40.Mr Spectroscopy and geometrical structure of clusters

36.40.Qv Stability and fragmentation of clusters

36.40.Sx Diffusion and dynamics of clusters

36.40.Vz Optical properties of clusters

36.40.Wa Charged clusters

36.90. +f Other topics in exotic atoms and molecules; macromolecules; clusters (restricted to new topics in section 36)

37. Mechanical control of atoms, molecules, and ions (see also 82.37.Gk STM and AFM manipulations of a single molecule in physical chemistry and chemical physics; for atom manipulation in nanofabrication and processing, see 81.16.Ta; see also 03.75. –b Matter waves)

37.10. –x Atom, molecule, and ion cooling methods (see also 87.80.Cc Optical trapping in biophysical techniques)

37.10.De Atom cooling methods

37.10.Gh Atom traps and guides

37.10.Jk Atoms in optical lattices

37.10.Mn Slowing and cooling of molecules

37.10.Pq Trapping of molecules

37.10.Rs Ion cooling

37.10.Ty Ion trapping

37.10.Vz Mechanical effects of light on atoms, molecules, and ions

37.20. +j Atomic and molecular beam sources and techniques

37.25. +k Atom interferometry techniques (see also 03.75.Dg Atom and neutron interferometry in matter waves)

37.30. +i Atoms, molecules, and ions in cavities (see also 42.50.Pq Cavity quantum electrodynamics; micromasers)

37.90. +j Other topics in mechanical control of atoms, molecules, and ions (restricted to new topics in section 37)
### 41. Electromagnetism; electron and ion optics

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### 41.85.Ne Electrostatic lenses, septa |

### 41.85.Qg Particle beam analyzers, beam monitors, and Faraday cups |

### 41.85.Si Particle beam collimators, monochromators |

### 41.90.−e Other topics in electromagnetism; electron and ion optics (restricted to new topics in section 41) |

#### 42. Optics (for optical properties of gases, see 51.70.−f; for optical properties of bulk materials and thin films, see 78.20.−e; for x-ray optics, see 41.50.+h) |

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45.80.+r Control of mechanical systems (see also 46.80.−r Measurement methods and techniques in continuum mechanics of solids)
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46. Continuum mechanics of solids
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46.50.+a Fracture mechanics, fatigue and cracks (see also 62.20.M− Structural failure of materials in mechanical properties of condensed matter)
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50. PHYSICS OF GASES, PLASMAS, AND ELECTRIC DISCHARGES

51. Physics of gases

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51.20. + d  Viscosity, diffusion, and thermal conductivity

51.30. + i  Thermodynamic properties, equations of state (see also 65.70.Ce Thermodynamic functions and equations of state in thermodynamics)

51.35. + a  Mechanical properties; compressibility

51.40. + p  Acoustical properties (see also 43.28. – q Aeroacoustics and atmospheric sound in Acoustics Appendix; for ultrasonic relaxation in gases, see 43.35.Fj— in Acoustics Appendix)

51.50. + v  Electrical properties (ionization, breakdown, electron and ion mobility, etc.) (see also 52.80. – s Electric discharges in physics of plasmas)

51.60. + a  Magnetic properties

51.70. + f  Optical and dielectric properties

51.80. + r  Other topics in the physics of gases (restricted to new topics in section 51)

52. Physics of plasmas and electric discharges (for space plasma physics, see 94.05. – a; for astrophysical plasmas, see 95.30.Qd; for physics of the ionosphere and magnetosphere, see 94.20. – y and 94.30. – d respectively)

52.20. – j  Elementary processes in plasmas

52.20. Dq  Particle orbits

52.20. Fz  Electron collisions

52.20. Hv  Atomic, molecular, ion, and heavy-particle collisions

52.25. – b  Plasma properties (for chemical reactions in plasma, see 82.33.Xj)

52.25. Dg  Plasma kinetic equations

52.25. Fi  Transport properties

52.25. Gj  Fluctuation and chaos phenomena (for plasma turbulence, see 52.35.Ra; see also 05.45. – a Nonlinear dynamics and chaos)

52.25. Jm  Ionization of plasmas

52.25. Kn  Thermodynamics of plasmas

52.25. Mq  Dielectric properties

52.25. Os  Emission, absorption, and scattering of electromagnetic radiation

52.25. Tx  Emission, absorption, and scattering of particles

52.25. Vy  Impurities in plasmas

52.25. Xz  Magnetized plasmas

52.25. Ya  Neutrals in plasmas

52.27. – h  Basic studies of specific kinds of plasmas

52.27. Aj  Single-component, electron-positive-ion plasmas

52.27. Cm  Multicomponent and negative-ion plasmas

52.27. Ep  Electron-positron plasmas

52.27. Gr  Strongly-coupled plasmas

52.27. Jt  Nonneutral plasmas

52.27. Lw  Dusty or complex plasmas; plasma crystals

52.27. Ny  Relativistic plasmas

52.30. – q  Plasma dynamics and flow

52.30. Cv  Magnetohydrodynamics (including electron magnetohydrodynamics) (see also 47.65. – d Magnetohydrodynamics and electrohydrodynamics in fluid dynamics; for MHD generators, see 52.75.Fk; see also 95.30.Qd Magnetohydrodynamics and plasmas in astrophysics)

52.30. Ex  Two-fluid and multi-fluid plasmas

52.30. Gz  Gyrokinetics

52.35. – g  Waves, oscillations, and instabilities in plasmas and intense beams (see also 94.20.vf Plasma waves and instabilities in physics of the ionosphere; 94.30.eg MHD waves, plasma waves, and instabilities in physics of the magnetosphere; 96.50.Tf MHD waves, plasma waves, turbulence in interplanetary physics)

52.35. Bj  Magnetohydrodynamic waves (e.g., Alfvén waves)

52.35. Dm  Sound waves

52.35. Fp  Electrostatic waves and oscillations (e.g., ion-acoustic waves)

52.35. Hr  Electromagnetic waves (e.g., electron-cyclotron, Whistler, Bernstein, upper hybrid, lower hybrid)

52.35. Kt  Drift waves

52.35. Lv  Other linear waves

52.35. Mw  Nonlinear phenomena: waves, wave propagation, and other interactions (including parametric effects, mode coupling, ponderomotive effects, etc.)

52.35. Py  Macroinstabilities (hydromagnetic, e.g., kink, fire-hose, mirror, ballooning, tearing, trapped-particle, flute, Rayleigh-Taylor, etc.)

52.35. Qz  Microinstabilities (ion-acoustic, two-stream, loss-cone, beam-plasma, drift, ion- or electron-cyclotron, etc.)

52.35. Ra  Plasma turbulence

52.35. Sb  Solitons; BGK modes

52.35. Tc  Shock waves and discontinuities

52.35. Vd  Magnetic reconnection (see also 94.30.eg in physics of the magnetosphere)

52.35. We  Plasma vorticity

52.38. – r  Laser–plasma interactions (for plasma production and heating by laser beams, see 52.50.Jm)

52.38. Bv  Rayleigh scattering; stimulated Brillouin and Raman scattering

52.38. Dx  Laser light absorption in plasmas (collisional, parametric, etc.)

52.38. Fz  Laser-induced magnetic fields in plasmas

52.38. Hb  Self-focussing, channeling, and filamentation in plasmas

52.38. Kd  Laser-plasma acceleration of electrons and ions (see also 41.75.Jv Laser-driven acceleration in electromagnetism; electron and ion optics)

52.38. Mf  Laser ablation (see also 79.20.Ds, Laser-beam impact phenomena)

52.38. Ph  X-ray, y-ray, and particle generation

52.40. – w  Plasma interactions (nonlaser)

52.40. Db  Electromagnetic (nonlaser) radiation interactions with plasma (for electromagnetic wave propagation in the ionosphere and magnetosphere, see 94.20.Bb and 94.30.T; respectively)

52.40. Dd  Plasma interactions with antennas; plasma-filled waveguides

52.40. Hf  Plasma—material interactions; boundary layer effects

52.40. Kh  Plasma sheaths (see also 94.30.eg Magnetosheath)

52.40. Mj  Particle beam interactions in plasmas

52.50. – b  Plasma production and heating (see also 52.80. – s Electric discharges)

52.50. Dg  Plasma sources

52.50. Gj  Plasma heating by particle beams

52.50. Jm  Plasma production and heating by laser beams (laser–foil, laser–cluster, etc.)

52.50. Lp  Plasma production and heating by shock waves and compression
| 52.50.Nr | Plasma heating by DC fields; ohmic heating, arcs |
| 52.50.Qt | Plasma heating by radio-frequency fields; ICR, ICP, helicons |
| 52.50.Sw | Plasma heating by microwaves; ECR, LH, collisional heating |
| 52.55.—s | Magnetic confinement and equilibrium (see also 28.52.—s Fusion reactors) |
| 52.55.Dy | General theory and basic studies of plasma lifetime, particle and heat loss, energy balance, field structure, etc. |
| 52.55.Ez | Theta pinch |
| 52.55.Fa | Tokamaks, spherical tokamaks |
| 52.55.Hc | Stellarators, toratsrons, heliacs, bumpy tori, and other toroidal confinement devices |
| 52.55.Ip | Spheromaks |
| 52.55.Jd | Magnetic mirrors, gas dynamic traps |
| 52.55.Lf | Field-reversed configurations, rotokamaks, astrons, ion rings, magnetized target fusion, and cusps |
| 52.55.Pi | Fusion products effects (e.g., alpha-particles, etc.), fast particle effects |
| 52.55.Rk | Power exhaust; divertors |
| 52.55.Tn | Ideal and resistive MHD modes; kinetic modes |
| 52.55.Wq | Current drive; helicity injection |
| 52.65.—y | Plasma simulation |
| 52.70.—m | Plasma diagnostic techniques and instrumentation |
| 52.72.+v | Laboratory studies of space- and astrophysical-plasma processes (see also 94.05.Rx in space plasma physics) |
| 52.75.—d | Plasma devices (for ion sources, see 29.25.Lg, Ni; for plasma sources, see 52.50.Dg) |
| 52.75.Di | Ion and plasma propulsion |
| 52.75.Fk | Magnetohydrodynamic generators and thermonic convertors; plasma diodes (see also 84.60.Lw, Nl in direct-energy conversion and storage) |
| 52.75.Hn | Plasma torches |
| 52.75.Kq | Plasma switches (e.g., spark gaps) |
| 52.75.Xx | Thermonic and filament-based sources (e.g., Q machines, double- and triple-plasma devices, etc.) |
| 52.77.—j | Plasma applications |
| 52.77.Bn | Etching and cleaning (see also 81.65.Cj Surface cleaning, etching, patterning in surface treatments) |
| 52.77.Dq | Plasma-based ion implantation and deposition (see also 81.15.Jf Ion and electron beam-assisted deposition) |
| 52.77.Fv | High-pressure, high-current plasmas (plasma spray, arc welding, etc.) (see also 81.15.Rs Spray coating techniques) |
| 52.80.—s | Electric discharges (see also 51.50.+v Electrical properties of gases; for plasma reactions including flowing afterglow and electric discharges, see 82.33.Xj in physical chemistry and chemical physics) |
| 52.80.Dy | Low-field and Townsend discharges |
| 52.80.He | Glow; corona |
| 52.80.Mg | Arcs; sparks; lightning; atmospheric electricity (see also 92.60.Pw Atmospheric electricity, lightning in meteorology) |
| 52.80.Pi | High-frequency and RF discharges |
| 52.80.Qj | Explosions; exploding wires |
| 52.80.Sm | Magetnoactive discharges (e.g., Penning discharges) |
| 52.80.Tn | Other gas discharges |
| 52.80.Vp | Discharge in vacuum |
| 52.80.Wq | Discharge in liquids and solids (for electric breakdown in liquids, see 77.22.Jp) |
| 52.80.Yr | Discharges for spectral sources (including inductively coupled plasma) |
| 52.90.+z | Other topics in physics of plasmas and electric discharges (restricted to new topics in section 52) |
61. Structure of solids and liquids; crystallography (for surface, interface, and thin film structure, see section 68)

61.05.-a Techniques for structure determination

61.05.C- X-ray diffraction and scattering (for x-ray diffractometers, see 07.85.Jv; for x-ray studies of crystal defects, see 61.72.Dd, Fj)

61.05.cc Theories of x-ray diffraction and scattering

61.05.cf X-ray scattering (including small-angle scattering)

61.05.cj X-ray absorption spectroscopy: EXAFS, XANES, etc. (for x-ray and EXAFS applications in biological physics, see 87.64.kd)

61.05.cm X-ray reflectometry (surfaces, interfaces, films)

61.05.cp X-ray diffraction

61.05.F- Neutron diffraction and scattering

61.05.fd Theories of neutron diffraction and scattering

61.05.fg Neutron scattering (including small-angle scattering)

61.05.fj Neutron reflectometry

61.05.fm Neutron diffraction

61.05.J- Electron diffraction and scattering (for electron diffractometers, see 07.78.+s)

61.05.jd Theories of electron diffraction and scattering

61.05.jh Low-energy electron diffraction (LEED) and reflection high-energy electron diffraction (RHEED)

61.05.jm Convergent-beam electron diffraction, selected-area electron diffraction, nanodiffraction

61.05.jp Electron holography

61.05.js X-ray photoelectron diffraction

61.05.Np Atom, molecule, and ion scattering (for structure determination only)

61.05.Qr Magnetic resonance techniques; Mössbauer spectroscopy (for structure determination only)

61.20.-p Structure of liquids

61.20.Gy Theory and models of liquid structure

61.20.Ja Computer simulation of liquid structure

61.20.Le Time-dependent properties; relaxation (for glass transitions, see 64.70.P—)

61.20.Ne Structure of simple liquids

61.20.Qg Structure of associated liquids; electrolytes, molten salts, etc.

61.25.—f Studies of specific liquid structures

61.25.Bi Liquid noble gases

61.25.Em Molecular liquids

61.25.H- Macromolecular and polymers solutions; polymer melts

61.25.he Polymer solutions

61.25.hk Polymer melts and blends

61.25.hp Polymer swelling, cross linking

61.25.Mv Liquid metals and alloys

61.30.—v Liquid crystals (for phase transitions in liquid crystals, see 64.70.M-; for liquid crystals as dielectric materials, see 77.84.Nh; for liquid crystals as optical materials, see 42.70.Df; for liquid crystal devices, see 42.79.Kr)

61.30.Cz Molecular and microscopic models and theories of liquid crystal structure

61.30.Dk Continuum models and theories of liquid crystal structure

61.30.Eb Experimental determinations of smectic, nematic, cholesteric, and other structures

61.30.Gd Orientational order of liquid crystals; electric and magnetic field effects on order

61.30.Hn Surface phenomena: alignment, anchoring, anchoring transitions, surface-induced ordering, wetting, prewetting transitions, and wetting transitions

61.30.Jf Defects in liquid crystals

61.30.Mp Blue phases and other defect-phases

61.30.Pq Microconfined liquid crystals: droplets, cylinders, randomly confined liquid crystals, polymer dispersed liquid crystals, and porous systems

61.30.St Lyotropic phases

61.30.Vx Polymer liquid crystals

61.41.+e Polymers, elastomers, and plastics (see also 81.05.Lq in materials science; for rheology of polymers, see section 83; for polymer reactions and polymerization, see 82.35.—x in physical chemistry and chemical physics)

61.43.—j Disordered solids (see also 81.05.Gc Amorphous semiconductors, 81.05.Kf Glasses, and 81.05.Rn Porous materials; granular materials in materials science; for photoluminescence of disordered solids, see 78.55.Mb and 78.55.Qr)

61.43.Bn Structural modeling: serial-addition models, computer simulation

61.43.Dq Amorphous semiconductors, metals, and alloys

61.43.Er Other amorphous solids

61.43.Fs Glasses

61.43.Gt Powders, porous materials

61.43.Hv Fractals; macroscopic aggregates (including diffusion-limited aggregates)

61.44.—n Semi-periodic solids

61.44.Br Quasicrystals

61.44.Fw Incommensurate crystals

61.46.—w Structure of nanoscale materials (for thermal properties of nanocrystals and nanotubes, see 65.80.+m; for mechanical properties of nanoscale systems, see 62.25.—g; for electronic transport in nanoscale materials, see 73.63.—h; see also 62.23.—c Structural classes of nanoscale systems; 64.70.Nd Structural transitions in nanoscale materials)

61.46.Bc Structure of clusters (e.g., metcarb; not fragments of crystals; free or loosely aggregated or loosely attached to a substrate) (see also 61.48.—c for structure of fullerences)

61.46.Df Structure of nanocrystals and nanoparticles ("colloidal" quantum dots but not gate-isolated embedded quantum dots)

61.46.Fg Nanotubes

61.46.Hk Nanocrystals

61.46.Km Structure of nanowires and nanorods (long, free or loosely attached, quantum wires and quantum rods, but not gate-isolated embedded quantum wires)

61.46.Np Structure of nanotubes (hollow nanowires) (see 64.18.De for carbon nanotubes, boron nanotubes, and closely related graphitelike systems)

61.48.—c Structure of fullerenes and related hollow molecular clusters (see also 81.05.Tp Fullerenes and related materials in materials science)

61.48.De Structure of carbon nanotubes, boron nanotubes, and closely related graphitelike systems (for structure of hollow nanowires, see 61.46.Np)

61.50.—f Structure of bulk crystals

61.50.Ah Theory of crystal structure, crystal symmetry; calculations and modeling

61.50.Ks Crystallographic aspects of phase transformations; pressure effects (see also 81.30.Hd in materials science)
61.50.Lt Crystal binding; cohesive energy
61.50.Nw Crystal stoichiometry

61.66.--f Structure of specific crystalline solids (for surface structure, see 68.35.B--)
61.66.Bi Elemental solids
61.66.Dk Alloys
61.66.Fn Inorganic compounds
61.66.Hq Organic compounds

61.68.+n Crystallographic databases

61.72.--y Defects and impurities in crystals; microstructure (for radiation induced defects, see 61.80.--x; for defects in surfaces, interfaces, and thin films, see 68.35.Dv and 68.55.Ln; see also 85.40.Rv Impurity doping, diffusion, and ion implantation technology)
61.72.Bb Theories of defect formation and annealing
61.72.Cc Kinetics of defect formation and annealing
61.72.Dd Experimental determination of defects by diffraction and scattering
61.72.Ff Direct observation of dislocations and other defects (etch pits, decoration, electron microscopy, x-ray topography, etc.)
61.72.Hh Indirect evidence of dislocations and other defects (resistivity, slip, creep, strains, internal friction, EPR, NMR, etc.)
61.72.J– Point defects and defect clusters
61.72.jd Vacancies
61.72.ji Interstitials
61.72.jn Color centers
61.72.Lk Linear defects: dislocations, disclinations
61.72.MM Grain and twin boundaries
61.72.Nn Stacking faults and other planar or extended defects
61.72.Oq Microscopic defects (voids, inclusions, etc.)
61.72.S– Impurities in crystals
61.72.sd Impurity concentration
61.72.sh Impurity distribution
61.72.sm Impurity gradients
61.72.U– Doping and impurity implantation
61.72.uf Ge and Si
61.72.uj III–V and II–VI semiconductors
61.72.up Other materials
61.72.Yx Interaction between different crystal defects; gettering effect

61.80.--x Physical radiation effects, radiation damage (for photochemical reactions, see 82.50.--m; for effects of ionizing radiation on biological systems, see 87.53.--j)

61.80.Az Theory and models of radiation effects
61.80.Ba Ultraviolet, visible, and infrared radiation effects (including laser radiation)
61.80.Cb X-ray effects
61.80.Ed y-ray effects
61.80.Fc Electron and positron radiation effects
61.80.Hg Neutron radiation effects
61.80.Jh Ion radiation effects (for ion implantation, see 61.72.U–)
61.80.Lj Atom and molecule irradiation effects

61.85.+p Channeling phenomena (blocking, energy loss of particles, see 61.80.+p)

61.85.--d Radiation effects on specific materials
61.85.Bg Metals and alloys
61.85.Fk Semiconductors
61.85.Ms Insulators
61.85.Pv Polymers, organic compounds
61.85.Rx Nanocrystalline materials

61.90.+d Other topics in structure of solids and liquids; crystallography (restricted to new topics in section 61)

62. Mechanical and acoustical properties of condensed matter

62.10.+s Mechanical properties of liquids (for viscosity of liquids, see 66.20.--d)

62.20.--x Mechanical properties of solids
62.20.B– Elasticity (for materials treatment effects on elastic properties, see 81.40.Lj)
62.20.de Elastic moduli
62.20.dj Poisson’s ratio

62.20.dq Other elastic constants
62.20.F– Deformation and plasticity (see also 83.50.--v Deformation and flow in rheology; for materials treatment effects on deformation, see 81.40.Lm)
62.20.gt Shape-memory effect; yield stress; superelasticity
62.20.kk Ductility, malleability
62.20.mq Plasticity and superplasticity
62.20.Hg Creep
62.20.M– Structural failure of materials (for materials treatment effects on microstructure, see 81.40.Np)
62.20.me Fatigue
62.20.mj Brittleness
62.20.mm Fracture
62.20.mq Buckling
62.20.mt Cracks
62.20.Qp Friction, tribology, and hardness (see also 46.55.+d Tribology and mechanical contacts in continuum mechanics of solids; for materials treatment effects on friction related properties, see 81.40.Pq)

62.23.--c Structural classes of nanoscale systems (see also 81.07.-b Nanoscale materials and structures: fabrication and characterization in materials science)
62.23.Eg Nanodots
62.23.Hj Nanowires
62.23.Kn Nanosheets
62.23.Pq Composites (nanosystems embedded in a larger structure)
62.23.St Complex nanostructures, including patterned or assembled structures

62.25.--g Mechanical properties of nanoscale systems (for structure of nanoscale systems, see 61.46.--w; for structural transitions in nanoscale materials, see 64.70.Nd; for electronic transport in nanoscale systems, see 73.63.--b)
62.25.De Low-frequency properties: response coefficients
62.25.Fg High-frequency properties, responses to resonant or transient (time-dependent) fields
62.25.Jk Mechanical modes of vibration
62.25.Mn Fracture/brittleness

62.30.+d Mechanical and elastic waves; vibrations (see also 43.40.+s Structural acoustics and vibration; 46.40.+f Vibrations and mechanical waves in continuum mechanics of solids)

62.40.+i Anelasticity, internal friction, stress relaxation, and
63. Lattice dynamics (see also 78.30.\textemdash j Infrared and Raman spectra; for surface and interface vibrations, see 68.35.Ja; for adsorbate vibrations, see 68.43.Pq; for lattice dynamics of quantum solids, see 67.80.de)

63.10.+a General theory

63.20.\textemdash e Phonons in crystal lattices (for phonons in superconductors, see 74.25.Kc; see also 43.35.Gk Phonons in crystal lattice, quantum acoustics—In Acoustics Appendix)

63.20.D\textemdash Phonon states and bands, normal modes, and phonon dispersion
63.20.dd Measurements
63.20.dh Fitted theory
63.20.dk First-principles theory
63.20.K\textemdash Phonon interactions
63.20.kd Phonon-electron interactions
63.20.kg Phonon-phonon interactions
63.20.\textemdash Phophon interactions with other quasiparticles
63.20.kp Phonon-defect interactions
63.20.Rw Localized modes
63.20.Ry Anharmonic lattice modes

63.22.\textemdash m Phonons or vibrational states in low-dimensional structures and nanoscale materials
63.22.Dc Free films
63.22.Gh Nanotubes and nanowires
63.22.Kn Clusters and nanocrystals
63.22.Np Layered systems

63.50.\textemdash x Vibration states in disordered systems
63.50.Gh Disordered crystalline alloys
63.50.Lm Glasses and amorphous solids

63.70.\textemdash h Statistical mechanics of lattice vibrations and displacive phase transitions

63.90.\textemdash t Other topics in lattice dynamics (restricted to new topics in section 63)

64. Equations of state, phase equilibria, and phase transitions (see also 82.60.\textemdash s Chemical thermodynamics)

64.10.\textemdash h General theory of equations of state and phase equilibria (see also 05.70.Ce Thermodynamic functions and equations of state)

64.30.\textemdash t Equations of state of specific substances
64.30.Ef Equations of state of pure metals and alloys
64.30.Jk Equations of state of nonmetals

64.60.\textemdash i General studies of phase transitions (see also 63.70.\textemdash h Statistical mechanics of lattice vibrations and displacive phase transitions; for critical phenomena in solid surfaces and interfaces, and in magnetism, see 68.35.Rh, and 75.40.\textemdash s, respectively)

64.60.A\textemdash Specific approaches applied to studies of phase transitions
64.60.\textemdash Renormalization-group theory
64.60.\textemdash Percolation
64.60.\textemdash Fractal and multifractal systems (see also 61.43.Hv Fractals; macroscopic aggregates)
64.60.\textemdash Finite-size systems
64.60.\textemdash Networks
64.60.\textemdash Convolution
64.60.\textemdash Cracks, sandpiles, avalanches, and earthquakes (for general studies of sandpiles and avalanches, see 45.70.Cc, Ht in classical mechanics of discrete systems; see also 91.30.Px Earthquakes in geophysics)
64.60.\textemdash General theory of phase transitions
64.60.\textemdash Order-disorder transformations (see also 81.30.Hd Constant-composition solid-solid phase transformations; polymorphic, massive, and order-disorder in materials science)
64.60.\textemdash Statistical mechanics of model systems (Ising model, Potts model, field-theory models, Monte Carlo techniques, etc)
64.60.\textemdash Studies/theory of phase transitions of specific substances
64.60.\textemdash Equilibrium properties near critical points, critical exponents
64.60.\textemdash General theory of critical region behavior
64.60.\textemdash Studies of specific substances in the critical region
64.60.\textemdash Properties of quantum fluids, see section 67
64.60.\textemdash Dynamic critical phenomena
64.60.\textemdash Multicritical points
64.60.\textemdash Metastable phases
64.60.\textemdash Nucleation (see also 82.60.Nh Thermodynamics of nucleation in physical chemistry and chemical physics)
64.60.\textemdash General theory and computer simulations of nucleation
64.60.\textemdash Studies of nucleation in specific substances
64.70.\textemdash Specific phase transitions
64.70.\textemdash Solid-liquid transitions
64.70.\textemdash Crystallization of specific substances
64.70.\textemdash Melting of specific substances
64.70.\textemdash General theory of the solid-liquid transition
64.70.\textemdash Liquid–vapor transitions
64.70.\textemdash Boiling and bubble dynamics (for bubble formation, bubble dynamics, boiling and cavitation, see section 47.35.D\textemdash; for acoustic cavitation, see 43.35.Ei see Acoustic Appendix
64.70.\textemdash Thermodynamics studies of
evaporation and condensation (for evaporation and condensation on surfaces, see 68.03.Fg)

64.70.Hz Solid–vapor transitions
64.70.Ja Liquid–vapor transitions
64.70.K– Solid–solid transitions (see also 61.50.Ks Crystallographic aspects of phase transformations; pressure effects; 75.30.Kz and 77.80.Bh for magnetic and ferroelectric transitions, respectively; for materials science aspects, see 81.30.—i)
64.70.kd Metals and alloys
64.70.kg Molecular crystals
64.70.ks Polymers
64.70.kp Ionic crystals
64.70.kq Glasses
64.70.kr Nonmetallic glasses (silicates, oxides, selenides, etc)
64.70.kr Molecular crystals
64.70.kr Transitions in liquid crystals
64.70.ky Theory and modeling of specific liquid crystal transitions, including computer simulation
64.70.m– Structural transitions in nanoscale materials
64.70.m– Glass transitions of specific systems
64.70.mh Metallurgical glasses
64.70.mh Nonmetallic glasses (silicates, oxides, selenides, etc)
64.70.mj Polymers
64.70.jp Polymers
64.70.mm Liquids
64.70.mp Liquid crystals (see also 64.70.m– Transitions in liquid crystals)
64.70.mq Granules
64.70.mv Colloids
64.70.n– Theory and modeling of the glass transition
64.70.nb Thermodynamics and statistical mechanics
64.70.nb Dynamics and criticality
64.70.nh Commensurate–incommensurate transitions
64.70.nj Quantum phase transitions (for quantum Hall effects aspects, see 73.43.Nq in electronic structure of quantum Hall emitters, see biological physics)
64.75.—g Phase equilibria (see also 82.60.lf Thermodynamics of solutions; 47.51.+a Mixing in fluid dynamics; for properties of solutions of biomolecules, see 87.15.N— in biological physics)
64.75.Bc Solubility
64.75.Cd Phase equilibria of fluid mixtures, including gases, hydrates, etc.
64.75.Ef Mixing
64.75.Gh Phase separation and segregation in model systems (hard spheres, Lennard-Jones, etc.)
64.75.Jk Phase separation and segregation in nanoscale systems (for general nanoscale materials studies, see 81.07.—b in materials science)
64.75.Lm Phase separation and segregation in oxidation (for general surface oxidation studies in surface treatments, see 81.65.Mq)
64.75.Nx Phase separation and segregation in solid solutions
64.75.Op Phase separation and segregation in alloying
64.75.Qt Phase separation and segregation in semiconductors
64.75.St Phase separation and segregation in thin films
64.75.Va Phase separation and segregation in polymer blends/polymeric solutions
64.75.Xc Phase separation and segregation in colloidal systems
64.75.Yz Self-assembly
64.90.—b Other topics in equations of state, phase equilibria, and phase transitions (restricted to new topics in section 64)

65. Thermal properties of condensed matter (see also section 44 Heat transfer; for thermodynamic properties of quantum fluids and solids, see section 67; for thermal properties of thin films, see 68.60.Dv; for nonelectronic thermal conduction, see 66.25.+g and 66.70.—f; for thermal properties of rocks and minerals, see 91.60.Ki; for thermodynamic properties of superconductors, see 74.25.Bt; see also 81.19.Fp Biotechnics and thermal processes in biological physics)

65.20.—w Thermal properties of liquids
65.20.De General theory of thermodynamic properties of liquids, including computer simulation
65.20.Jk Studies of thermodynamic properties of specific liquids

65.40.—b Thermal properties of crystalline solids (for specific heat of superconductors, see 74.25.Bt; for specific heat of magnetic systems, see 75.40.Cx)
65.40.Ba Heat capacity
65.40.De Thermal expansion; thermomechanical effects
65.40.G– Other thermodynamical quantities (for magnetocaloric effect, see 75.30.Sg; for properties of dielectrics, ferroelectrics, and piezoelectrics, see section 77)
65.40.gd Entropy
65.40.gh Work functions

66. Nonelectronic transport properties of condensed matter

66.10.—x Diffusion and ionic conduction in liquids
66.10.C– Diffusion and thermal diffusion (for osmosis in biological systems, see 82.39.W) in physical chemistry; for cellular transport, see 87.16.dp and 87.16.Uv in biological physics)
66.10.cd Thermal diffusion and diffusive energy transport
66.10.cg Mass diffusion, including self-diffusion, mutual diffusion, tracer diffusion, etc.
66.10.Ed Ionic conduction
66.20.—d Viscosity of liquids; diffusive momentum transport
66.20.Cy Theory and modeling of viscosity and rheological properties, including computer simulation
66.20.Ej Studies of viscosity and rheological properties of specific liquids
66.20.Gd Diffusive momentum transport
66.25.—e Thermal conduction in nonmetallic liquids (for thermal conduction in liquid metals, see 72.15.Cz)
66.30.—h Diffusion in solids (for surface and interface diffusion, see 68.35.Fx)
66.30.Dn Theory of diffusion and ionic conduction in solids
66.30.Fq Self-diffusion in metals, semimetals, and alloys
66.30.H Self-diffusion and ionic conduction in nonmetals
66.30.hd Ionic crystals
66.30.hh Glasses
66.30.hk Polymers
66.30.hp Molecular crystals
| 66.30.J | Diffusion of impurities (for surface diffusion, hopping, sorption, etc., see 68.35.Fx; see section 72 for carrier diffusion and electron-hole diffusion) |
| 66.30.je | Diffusion of gases |
| 66.30.jp | Diffusion of water |
| 66.30.Lw | Proton diffusion |
| 66.30.Ma | Diffusion of other defects |
| 66.30.Ny | Chemical interdiffusion; diffusion barriers |
| 66.30.Pa | Diffusion in nanoscale solids |
| 66.30.Qa | Electromigration |
| 66.30.Xj | Thermal diffusivity |
| 66.35.+a | Quantum tunneling of defects |
| 66.70.−f | Nonelectronic thermal conduction and heat-pulse propagation in solids; thermal waves (for electronic thermal conduction in metals and alloys, see 72.15.Cz and 72.15.Eb) |
| 66.70.Df | Metals, alloys, and semiconductors |
| 66.70.Hk | Glasses and polymers |
| 66.70.Lm | Other systems such as ionic crystals, molecular crystals, nanotubes, etc. |
| 66.90.+r | Other topics in nonelectronic transport properties of condensed matter (restricted to new topics in section 66) |

### 67. Quantum fluids and solids (see also 05.30.−d Quantum statistical mechanics; for cryogenics, refrigerators, low-temperature detectors, and other low temperature equipment, see 07.20.Mc; see also 47.37.+q Hydrodynamic aspects of superfluidity; quantum fluids—in fluid dynamics) |

#### 67.10.−j Quantum fluids: general properties |
| 67.10.Ba | Boson degeneracy (for ultracold, trapped gases, see 67.85.−d) |
| 67.10.Db | Fermion degeneracy |
| 67.10.Fj | Quantum statistical theory |
| 67.10.Hk | Quantum effects on the structure and dynamics of non-degenerate fluids |
| 67.10.Jn | Transport properties and hydrodynamics |

#### 67.25.+k $^4$He |
| 67.25.B− | Normal phase of $^4$He |
| 67.25.bd | Thermodynamic properties |
| 67.25.bf | Transport, hydrodynamics |
| 67.25.bh | Films and restricted geometries |

#### 67.25.D− Superfluid phase |
| 67.25.de | Thermodynamic properties |
| 67.25.dg | Transport, hydrodynamics, and superflow |
| 67.25.dj | Superfluid transition and critical phenomena |
| 67.25.dk | Vortices and turbulence |
| 67.25.dm | Two-fluid model; phenomenology |
| 67.25.dp | Films |
| 67.25.dr | Restricted geometries |
| 67.25.dt | Sound and excitations |
| 67.25.du | Relaxation phenomena |
| 67.25.dw | Superfluidity in small clusters |

#### 67.30.+n $^3$He |
| 67.30.E− | Normal phase of $^3$He |
| 67.30.ef | Thermodynamics |
| 67.30.eh | Transport and hydrodynamics |
| 67.30.ej | Films and restricted geometries |
| 67.30.em | Excitations |
| 67.30.ep | Spin polarized $^3$He |
| 67.30.er | Magnetic properties, NMR |
| 67.30.H− | Superfluid phase of $^3$He |
| 67.30.hb | Transport, hydrodynamics, and superflow |
| 67.30.he | Textures and vortices |
| 67.30.hj | Spin dynamics |
| 67.30.hm | Impurities |
| 67.30.hp | Interfaces |
| 67.30.hr | Films |
| 67.30.ht | Restricted geometries |

#### 67.60.+g Mixtures of $^3$He and $^4$He |
| 67.60.Bc | Bose mixtures |
| 67.60.Fp | Bose-Fermi mixtures |
| 67.60.G− | Solutions of $^3$He in liquid $^4$He |
| 67.60.gc | Spin-polarized solutions |
| 67.60.hb | Transport and hydrodynamics |
| 67.60.he | Films |

#### 67.63.+r Hydrogen and isotopes |
| 67.63.Cd | Molecular hydrogen and isotopes |
| 67.63.Gh | Atomic hydrogen and isotopes |

#### 67.80.+s Quantum solids |
| 67.80.B− | Solid $^3$He |
| 67.80.bd | Superfluidity in solid $^3$He, supersolid $^4$He |
| 67.80.bf | Liquid-solid interfaces; growth kinetics |
| 67.80.D− | Solid $^3$He |
| 67.80.de | Structure, lattice dynamics and sound |
| 67.80.dj | Defects, impurities, and diffusion |
| 67.80.dk | Magnetic properties, phases, and NMR |
| 67.80.dm | Films |
| 67.80.F− | Solids of hydrogen and isotopes |
| 67.80.ff | Molecular hydrogen and isotopes |
| 67.80.fh | Atomic hydrogen and isotopes |
| 67.80.K− | Other supersolids |
| 67.80.kb | Supersolid phases on lattices |

#### 67.85.+d Ultracold gases, trapped gases (see also 02.75.−b Matter waves in quantum mechanics) |
| 67.85.Bc | Static properties of condensates |
| 67.85.De | Dynamic properties of condensates; excitations, and superfluid flow |
| 67.85.Fg | Multicomponent condensates; spinor condensates |
| 67.85.Hj | Bose–Einstein condensates in optical potentials |
| 67.85.Lm | Degenerate Fermi gases |
| 67.85.Pq | Mixtures of Bose and Fermi gases |
| 67.90.+z | Other topics in quantum fluids and solids (restricted to new topics in section 67) |

### 68. Surfaces and interfaces; thin films and nanosystems (structure and nonelectronic properties) (for surface and interface chemistry, see 82.65.+r; for surface magnetism, see 75.70.Rf) |

#### 68.03.+g Gas-liquid and vacuum-liquid interfaces |
| 68.03.Cd | Surface tension and related phenomena |
| 68.03.Fg | Evaporation and condensation of liquids |
| 68.03.Hj | Liquid surface structure: measurements and simulations |
| 68.03.Kn | Dynamics (capillary waves) |

#### 68.05.+n Liquid-liquid interfaces |
| 68.05.Cf | Liquid-liquid interface structure: measurements and simulations |
| 68.05.Gh | Interfacial properties of microemulsions |

#### 68.08.+p Liquid-solid interfaces |
| 68.08.Bc | Wetting |
| 68.08.De | Liquid-solid interface structure: measurements and simulations (for crystal growth from solutions and melts, see 81.10.Dn, Fq in materials science) |

#### 68.15.+e Liquid thin films |
| 68.18.+g Langmuir-Blodgett films on liquids (for L-B films on solids, see 68.47.Pe) |
| 68.18.Fg | Liquid thin film structure: measurements and simulations |
| 68.18.Jk | Phase transitions in liquid thin films |

#### 68.35.+p Solid surfaces and solid–solid interfaces: structure and energetics |
<p>| 68.35.Af | Atomic scale friction |
| 68.35.B− | Structure of clean surfaces (and surface reconstruction) |
| 68.35.bd | Metals and alloys |</p>
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### 70. CONDENSED MATTER: ELECTRONIC STRUCTURE, ELECTRICAL, MAGNETIC, AND OPTICAL PROPERTIES

#### 71. Electronic structure of bulk materials

- **71.20.Dg** Alkali and alkaline earth metals
- **71.20.Eh** Rare earth metals and alloys
- **71.20.Gj** Other metals and alloys
- **71.20.Lp** Intermetallic compounds
- **71.20.Mq** Elemental semiconductors
- **71.20.Nr** Semiconductor compounds
- **71.20.Ps** Other inorganic compounds
- **71.20.Rv** Polymers and organic compounds
- **71.20.Tx** Fullerenes and related materials; intercalation compounds

#### 71.12.+i Electronic structure of liquid metals and semiconductors and their alloys

- **71.23.–k** Electronic structure of disordered solids
- **71.23.An** Theories and models; localized states
- **71.23.Cq** Amorphous semiconductors, metallic glasses, glasses
- **71.23.Ft** Quasicrystals

#### 71.70.+a Strongly correlated electron systems; heavy fermions

- **71.28.+d** Narrow-band systems; intermediate-valence solids (for magnetic aspects, see 75.20.Hr and 75.30.Mb in magnetic properties and materials)

#### 71.30.+h Metal–insulator transitions and other electronic transitions

- **71.35.–y** Excitons and related phenomena
- **71.35.Aa** Frenkel excitons and self-trapped excitons
- **71.35.Cc** Intrinsic properties of excitons; optical absorption spectra
- **71.35.Ee** Electron-hole drops and electron-hole plasma
- **71.35.Gg** Exciton-mediated interactions
- **71.35.Ji** Excitons in magnetic fields; magnetoeffectoxitons
- **71.35.Lk** Collective effects (Bose effects, phase space filling, and excitonic phase transitions)
- **71.35.Pq** Charged excitons (trions)

#### 71.36.+c Polaritons (including photon–phonon and photon–magnon interactions)

- **71.38.–k** Polarons and electron-phonon interactions (see also 63.20.K– Phonon interactions in lattice dynamics)
- **71.38.Cn** Mass renormalization in metals
- **71.38.Fp** Large or Fröhlich polarons
- **71.38.Ht** Self-trapped or small polarons
- **71.38.Mx** Bipolarons

#### 71.45.–d Collective effects

- **71.45.Gm** Exchange, correlation, dielectric and magnetic response functions, plasmons
- **71.45.Lr** Charge-density-wave systems (see also 75.30.Fv Spin-density waves)

#### 71.55.–i Impurity and defect levels

- **71.55.Ak** Metals, semimetals, and alloys
- **71.55.Cn** Elemental semiconductors
- **71.55.Eq** III–V semiconductors
- **71.55.Gs** II–VI semiconductors
- **71.55.Ht** Other nonmetals
- **71.55.Jv** Disordered structures; amorphous and glassy solids

#### 71.60.+z Positron states (for positron annihilation, see 78.70.Bj)

#### 71.70.–d Level splitting and interactions

- **71.70.Ej** Spin–orbit coupling, Zeeman and Stark splitting, Jahn–Teller effect
- **71.70.Fk** Strain-induced splitting
- **71.70.Gm** Exchange interactions
- **71.70.Jp** Nuclear states and interactions

#### 71.90.+q Other topics in electronic structure (restricted to new topics in section 71)

#### 72. Electronic transport in condensed matter

- **72.10.Di** Scattering by phonons, magnons, and other nonlocalized excitations (see also 71.45.–d Collective effects in electronic structure of bulk materials)
### 73.40.Vz Semiconductor–metal–semiconductor structures

### 73.43.–f Quantum Hall effects

**73.43.Cd** Theory and modeling

**73.43.Fj** Novel experimental methods; measurements

**73.43.Jn** Tunneling

**73.43.Lp** Collective excitations

**73.43.Nq** Quantum phase transitions (see also 64.70.Tg Quantum phase transitions in equations of state, phase equilibria and phase transitions)

**73.43.Qt** Magnetoresistance (see also 75.47.–m Magnetotransport phenomena; materials for magnetotransport in magnetic properties and materials)

- **73.43.Nt** Optical properties, see 78.66.–w

### 73.50.–h Electronic transport phenomena in thin films (for electronic transport in mesoscopic systems, see 73.23.–b; see also 73.40.–c Electronic transport in interface structures; for electronic transport in nanoscale materials and structures, see 73.63.–b)

**73.50.Bk** General theory, scattering mechanisms

**73.50.Dn** Low-field transport and mobility; piezoresistance

**73.50.Fq** High-field and nonlinear effects

**73.50.Gr** Charge carriers: generation, recombination, lifetime, trapping, mean free paths

**73.50.Jt** Galvanomagnetic and other magnetotransport effects (including thermomagnetic effects)

**73.50.Lw** Thermoelectric effects

**73.50.Mx** High-frequency effects; plasma effects

**73.50.Pz** Photoconduction and photovoltaic effects

**73.50.Rb** Acoustoelectric and magnetoacoustic effects

**73.50.Td** Noise processes and phenomena

### 73.61.–r Electrical properties of specific thin films (for optical properties of thin films, see 78.20.–e and 78.66.–w; for magnetic properties of thin films, see 75.70.–i)

**73.61.At** Metal and metallic alloys

**73.61.Cw** Elemental semiconductors

**73.61.Ey** III–V semiconductors

**73.61.Ga** II–VI semiconductors

**73.61.Jc** Amorphous semiconductors; glasses

**73.61.Le** Other inorganic semiconductors

**73.61.Ng** Insulators

**73.61.Ph** Polymers; organic compounds

**73.61.Wp** Fullerenes and related materials

### 73.63.–b Electronic transport in nanoscale materials and structures

(see also 73.23.–b Electronic transport in mesoscopic systems)

**73.63.Bd** Nanocrystalline materials

**73.63.Fg** Nanotubes

**73.63.Hs** Quantum wells

**73.63.Kv** Quantum dots

**73.63.Nm** Quantum wires

**73.63.Rt** Nanoscale contacts

### 73.70. Other topics in electronic structure and electrical properties of surfaces, interfaces, thin films, and low-dimensional structures (Restricted to new topics in section 73)

### 74. Superconductivity

(see 78.20.–j)

#### 74.10.+v Occurrence, potential candidates

**74.10.De** Phenomenological theories (two-fluid, Ginzburg–Landau, etc.)

**74.10.Fg** BCS theory and its development

**74.10.Mn** Nonconventional mechanisms (spin fluctuations, polarons and bipolarons, resonating valence bond model, anyon mechanism, marginal Fermi liquid, Luttinger liquid, etc.)

**74.10.Rp** Pairing symmetries (other than s-wave)

#### 74.25.–q Properties of type I and type II superconductors

**74.25.Bt** Thermodynamic properties

**74.25.Dw** Superconductivity phase diagrams

**74.25.Fy** Transport properties (electric and thermal conductivity, thermoelectric effects, etc.)

**74.25.Gz** Optical properties

**74.25.Ha** Magnetic properties

**74.25.Jb** Electronic structure

**74.25.Kc** Phonons

**74.25.Ld** Mechanical and acoustical properties, elasticity, and ultrasonic attenuation

**74.25.Nf** Response to electromagnetic fields (nuclear magnetic resonance, surface impedance, etc.)

**74.25.Op** Mixed states, critical fields, and surface sheaths

**74.25.Qt** Vortex lattices, flux pinning, flux creep

**74.25.Sv** Critical currents

**74.40.+k** Fluctuations (noise, chaos, nonequilibrium superconductivity, localization, etc.)

### 74.45.+c Proximity effects; Andreev effect; SN and SNS junctions

### 74.50.+r Tunneling phenomena; point contacts, weak links, Josephson effects (for SQUIDs, see 85.25.Dg; for Josephson devices, see 85.25.Cp; for Josephson junction arrays, see 74.81.Fa)

### 74.62.–c Transition temperature variations

**74.62.Bf** Effects of material synthesis, crystal structure, and chemical composition

**74.62.Dh** Effects of crystal defects, doping and substitution

**74.62.Fj** Pressure effects

**74.62.Yb** Other effects

### 74.70.–b Superconducting materials (for cuprates, see 74.72.–h)

**74.70.Ad** Metals; alloys and binary compounds (including A15, MgB₂, etc.)

**74.70.Dd** Ternary, quaternary, and multinary compounds (including Chevrel phases, borocarbides, etc.)

**74.70.Kn** Organic superconductors

**74.70.Pq** Ruthenates

**74.70.Tx** Heavy-fermion superconductors

**74.70.Wz** Fullerenes and related materials

### 74.72.–h Cuprate superconductors (high-Tc and insulating parent compounds)

**74.72.Bk** Y-based cuprates

**74.72.Dn** La-based cuprates

**74.72.Hs** Bi-based cuprates

**74.72.Jt** Other cuprates, including Tl and Hg-based cuprates

### 74.78.–w Superconducting films and low-dimensional structures

**74.78.Bz** High-Tc films

**74.78.Db** Low-Tc films

**74.78.Fk** Multilayers, superlattices, heterostructures

**74.78.Na** Mesoscopic and nanoscale systems

### 74.81.–g Inhomogeneous superconductors and superconducting systems

**74.81.Bd** Granular, melt-textured, amorphous, and composite superconductors

**74.81.Fa** Josephson junction arrays and wire networks

### 74.90.+n Other topics in superconductivity (restricted to new topics in section 74)

### 75. Magnetic properties and materials

(see also 74.90.+n)

**75.40.Vz** Applications to superconductors

**75.40.Bf** Other magnetic properties

**75.40.Nk** Magnetic interactions

**75.40.Ps** Magnetic measurements

**75.40.Wz** Applications to electronic materials and devices

**75.40.Xy** Applications in materials science

**75.50.+e** Magnetic effects in solids

**75.60.+t** Magnetic effects in superconductors

**75.70.+o** Magnetic effects in superconducting systems

**75.78.+h** Magnetic phase transitions

**75.80.+e** Magnetic properties of quantum solids

**75.80.+k** Magnetic properties of quantum fluids

**75.90.+r** Magnetic properties in biological systems

**75.90.+u** Magnetic properties in materials science

**75.90.+v** Magnetic properties in materials science (for magnetic properties related to treatment conditions, see 81.40.Rs; for magnetic properties of quantum solids, see 67.80.dk; for magnetic properties of quantum fluids, see 67.80.kd)
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75.10.−b General theory and models of magnetic ordering (see also 05.50.+q Lattice theory and statistics)

75.10.Dg Crystal-field theory and spin Hamiltonians

75.10.Hk Classical spin models

75.10.Jm Quantized spin models

75.10.Lp Band and itinerant models

75.10.Nr Spin-glass and other random models

75.10.Pq Spin chain models

75.20.−g Diamagnetism, paramagnetism, and superparamagnetism

75.20.Ck Nonmetals

75.20.En Metals and alloys

75.20.Hr Local moment in compounds and alloys; Kondo effect, valence fluctuations, heavy fermions (see also 72.15.Qm Scattering mechanisms and Kondo effect)

75.25.+z Spin arrangements in magnetically ordered materials (including neutron and spin-polarized electron studies, synchrotron-source X-ray scattering, etc.) (for devices exploiting spin polarized transport, see 83.75.–d)

75.30.−m Intrinsic properties of magnetically ordered materials (for critical point effects, see 75.40.−s)

75.30.Cr Saturation moments and magnetic susceptibilities

75.30.Ds Spin waves (for spin-wave resonance, see 76.50.+g)

75.30.Et Exchange and superexchange interactions (see also 71.70.–d Level splitting and interactions)

75.30.Fv Spin-density waves

75.30.Gw Magnetic anisotropy

75.30.Hx Magnetic impurity interactions

75.30.Kz Magnetic phase boundaries (including magnetic transitions, metamagnetism, etc.)

75.30.Mb Valence fluctuation, Kondo lattice, and heavy-fermion phenomena (see also 71.27.+a Strongly correlated electron systems, heavy fermions)

75.30.Sg Magnetocaloric effect, magnetic cooling

75.30.Wx Spin crossover

75.40.−s Critical-point effects, specific heats, short-range order (see also 65.40.Ba Heat capacity)

75.40.Cx Static properties (order parameter, static susceptibility, heat capacities, critical exponents, etc.)

75.40.Gb Dynamic properties (dynamic susceptibility, spin waves, spin diffusion, dynamic scaling, etc.)

75.40.Mg Numerical simulation studies

75.45.+j Macroscopic quantum phenomena in magnetic systems

75.47.−m Magnetotransport phenomena; materials for magnetotransport (for spintronics, see 85.75.–d; see also 72.15.Gd, 73.50.Jh, 73.43.Qt, and 72.25.–b in transport phenomena)

75.47.De Giant magnetoresistance

75.47.Gk Colossal magnetoresistance

75.47.Jn Ballistic magnetoresistance

75.47.Lx Manganites

75.47.Np Metals and alloys

75.47.Pq Other materials

75.50.−y Studies of specific magnetic materials

75.50.Bb Fe and its alloys

75.50.Cc Other ferromagnetic metals and alloys

75.50.Da Nonmetallic ferromagnetic materials

75.50.Ee Antiferromagnetics

75.50.Gg Ferrimagnetics

75.50.Kj Amorphous and quasicrystalline magnetic materials

75.50.Lk Spin glasses and other random magnets

75.50.Mn Magnetic liquids

75.50.Pp Magnetic semiconductors

75.50.Ss Magnetic recording materials (see also 85.70.–w Magnetic devices)

75.50.Ti Fine-particle systems; nanocrystalline materials

75.50.Vv High coercivity materials

75.50.Ww Permanent magnets

75.50.Xx Molecular magnets

75.60.−d Domain effects, magnetization curves, and hysteresis

75.60.Ch Domain walls and domain structure (for magnetic bubbles, see 75.70.Kw)

75.60.Ej Magnetization curves, hysteresis, Barkhausen and related effects

75.60.Jk Magnetization reversal mechanisms

75.60.Lr Magnetic aftereffects

75.60.Nt Magnetic annealing and temperature–hysteresis effects

75.70.–i Magnetic properties of thin films, surfaces, and interfaces (for magnetic properties of nanostructures, see 75.75.+a)

75.70.Ak Magnetic properties of monolayers and thin films

75.70.Cn Magnetic properties of interfaces (multilayers, superlattices, heterostructures)

75.70.Kw Domain structure (including magnetic bubbles)

75.70.Rf Surface magnetism

75.75.+a Magnetic properties of nanostructures

75.80.+q Magnetomechanical and magnetoelectric effects, magnetostriiction

76. Magnetic resonances and relaxations in condensed matter, Mössbauer effect

76.20.+q General theory of resonances and relaxations

76.30.−v Electron paramagnetic resonance and relaxation (see also 33.35.+r Electron resonance and relaxation in atomic and molecular physics; 87.80.Lg Magnetic and paramagnetic resonance in biological physics)

76.30.Da Ions and impurities: general

76.30.Fc Iron group (3d) ions and impurities (Ti–Cu)

76.30.He Platinum and palladium group (4d and 5d) ions and impurities (Zr–Ag and Hf–Au)

76.30.Kg Rare-earth ions and impurities

76.30.Lh Other ions and impurities

76.30.Mi Color centers and other defects

76.30.Pk Conduction electrons

76.30.Rn Free radicals

76.40.+b Diamagnetic and cyclotron resonances

76.50.+g Ferromagnetic, antiferromagnetic, and ferrimagnetic resonances; spin-wave resonance (see also 75.50.De Spin waves)

76.60.−k Nuclear magnetic resonance and relaxation (see also 33.25.+k Nuclear resonance and relaxation in atomic and molecular physics and 82.56.–b Nuclear magnetic resonance in physical chemistry and chemical physics; for structure determination using magnetic resonance techniques, see 61.05.Qt; for biophysical applications, see 87.80.Lg)
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| 76.60.Es | Relaxation effects |
| 76.60.Gv | Quadrupole resonance |
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| 76.60.Lz | Spin echoes |
| 76.60.Pc | NMR imaging (for medical NMR imaging, see 87.61. –c) |
| 76.70.Dx | Electron resonance |
| 77. Dielectrics, piezoelectrics, and ferroelectrics and their properties (for conductivity phenomena, see 72.20. –i and 72.80. –r; for dielectric properties related to treatment conditions, see 81.40.Tv) |
| 77.22.–d | Dielectric properties of solids and liquids (for dielectric properties of tissues and organs, see 87.19.ef) |
| 77.22.Ch | Permittivity (dielectric function) |
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| 77.55.+f | Dielectric thin films |
| 77.65.–j | Piezoelectricity and electromechanical effects |
| 77.65.Bn | Piezoelectric and electrostrictive constants |
| 77.65.Dq | Acoustoelectric effects and surface acoustic waves (SAW) in |
| 77.65.Fs | Electromechanical resonance; quartz resonators |
| 77.65.Ly | Strain-induced piezoelectric fields |
| 77.80.Dj | Domain structure; hysteresis |
| 77.80.Ek | Optical activity |
| 77.80.Fm | Birefringence |
| 77.80.Hp | Piezo-, elasto-, and acoustooptical effects; photoacoustic effects |
| 77.80.Jq | Electrooptical effects |
| 77.80.Ls | Magnetooptical effects |
| 77.80.Nv | Thermooptical and photothermal effects |
| 78. Optical properties, condensed-matter spectroscopy and other interactions of radiation and particles with condensed matter |
| 78.20.–e | Optical properties of bulk materials and thin films (for optical properties related to materials treatment, see 81.40.Tv; for optical materials, see 42.70.–a; for optical properties of superconductors, see 74.25.Gz; for optical properties of rocks and minerals, see 91.60.Mk; for optical/infrared radiation effects on biological systems, see 87.50.W–) |
| 78.20.Bh | Theory, models, and numerical simulation |
| 78.20.Ci | Optical constants (including refractive index, complex dielectric constant, absorption, reflection and transmission coefficients, emissivity) |
| 78.47.Jf | Photon echoes |
| 78.47.jg | Transient grating spectroscopy |
| 78.47.jm | Quantum beats |
| 78.47.jp | Optical nutation |
| 78.47.js | Free polarization decay |
High resolution nonlinear optical spectroscopy

Hole burning spectroscopy

Four-wave mixing spectroscopy

Photoluminescence, properties and materials

Elemental semiconductors

Liquids

III–V semiconductors

II–VI semiconductors

Solid alkali halides

Other solid inorganic materials

Solid organic materials

Porous materials

Amorphous materials; glasses and other disordered solids

Other luminescence and radiative recombination

Electroluminescence

Cathodoluminescence, ionoluminescence

Thermoluminescence

Sonoluminescence, triboluminescence

Chemiluminescence (see also 42.55.Ks Chemical lasers)

Optical properties of specific thin films (for optical properties of low-dimensional, mesoscopic, and nanoscale materials, see 78.67–n; for optical properties of surfaces, see 78.68.+m)

Metals and metallic alloys

Elemental semiconductors and insulators

III–V semiconductors

II–VI semiconductors

Amorphous semiconductors; glasses

Other semiconductors

Insulators

Polymers; organic compounds

Composite materials

Fullerenes and related materials

Fine-particle systems

Optical properties of low-dimensional, mesoscopic, and nanoscale materials and structures

Nanocrystals and nanoparticles

Nanotubes

Quantum wells

Quantum dots

Multilayers; superlattices

Optical properties of surfaces

Interactions of particles and radiation with matter

Positron annihilation (for positron states, see 71.60.+z in electronic structure of bulk materials; for positronium chemistry, see 82.30.Gg in physical chemistry and chemical physics)

X-ray scattering

X-ray absorption spectra

X-ray emission spectra and fluorescence

Microwave and radio-frequency interactions

Neutron inelastic scattering

Other topics in optical properties, condensed matter spectroscopy and other interactions of particles and radiation with condensed matter (restricted to new topics in section 78)

Impact phenomena (including electron spectra and sputtering)

Theory of impact phenomena; numerical simulation

Laser-beam impact phenomena

Electron impact: Auger emission

Electron impact: secondary emission

Other electron-impact emission phenomena

Positron emission

Atomic, molecular, and ion beam impact and interactions with surfaces

Channeling, blocking, energy loss of particles, see 61.85.+p

Electron energy loss spectroscopy (see also 82.80.Pv Electron spectroscopy in physical chemistry and chemical physics; 34.80.–i Electron and positron scattering in atomic and molecular physics)

Thermionic emission

Photoemission and photoelectron spectra

Clean metal, semiconductor, and insulator surfaces

Adsorbed layers and thin films

Polymers; organic compounds

Disordered structures

Interfaces; heterostructures; nanostructures

Field emission, ionization, evaporation, and desorption

Exoelectron emission

Other topics in electron and ion emission by liquids and solids and impact phenomena (restricted to new topics in section 79)
81. Materials science

81.05. Specific materials; fabrication, treatment, testing, and analysis

- Superconducting materials, see 74.70. –b and 74.72. –h
- Magnetic materials, see 75.50. –y
- Optical materials, see 42.70. –a
- Dielectric, piezoelectric, and ferroelectric materials, see 77.84. –s
- Colloids, gels, and emulsions, see 82.70.Dd, Gg, Kj
- Biomaterials, see 87.85.J-
- Molecular sieves, zeolites, and other complex materials, see 82.75. –z

81.05.Bx Metals, semimetals, and alloys
81.05.Cy Elemental semiconductors
81.05.Dz III–VI semiconductors
81.05.Ea III–V semiconductors
81.05.Gc Amorphous semiconductors
81.05.Hd Other semiconductors
81.05.Je Ceramics and refractories (including borides, carbides, hydrides, nitrides, oxides, and silicides) (for ceramics in electrochemistry, see 82.45.Yp)
81.05.Kf Glasses (including metallic glasses)
81.05.Lg Polymers and plastics; rubber; synthetic and natural fibers; organometallic and organic materials (for polymers and organic materials in electrochemistry, see 82.45.Wx)
81.05.Mh Cerments, ceramic and refractory composites
81.05.Ni Dispersions, fiber-, and platelet-reinforced metal-based composites
81.05.Pj Glass-based composites, vitreoceramics
81.05.Qk Reinforced polymers and polymer-based composites
81.05.Rm Porous materials; granular materials (for granular superconductors, see 74.81.Bd)
81.05.Tp Fullerenes and related materials
81.05.Uw Carbon, diamond, graphite
81.05.Zx New materials; theory, design, and fabrication

81.07. Nanoscale materials and structures; fabrication and characterization (for structure of nanoscale materials, see 61.46. –w; for nanostructured materials in electrochemistry, see 82.45.Yz; for nanoparticles in polymers, see 82.35.Np in physical chemistry and chemical physics; see also 62.23. –c Structural classes of nanoscale systems in mechanical properties of condensed matter)

81.07.Bc Nanocrystalline materials
81.07.De Nanotubes
81.07.Lk Nanocontacts
81.07.Nb Molecular nanostructures
81.07.Pr Organic-inorganic hybrid nanostructures
81.07.St Quantum wells
81.07.Ta Quantum dots
81.07.Vb Quantum wires
81.07.Wx Nanopowders

81.10. Methods of crystal growth; physics of crystal growth (for crystal structure, see section 61)

81.10.Aj Theory and models of crystal growth; physics of crystal growth, crystal morphology, and orientation
81.10.Bk Growth from vapor
81.10.Dn Growth from solutions
81.10.Fq Growth from melts; zone melting and refining
81.10.Jt Growth from solid phases (including multiphase diffusion and recrystallization)
81.10.Ms Growth in microgravity environments

81.15. Methods of deposition of films and coatings; film growth and epitaxy (for structure of thin films, see 68.55. –a; see also 85.40.Sz Deposition technology in microelectronics)

81.15.Aa Theory and models of film growth
81.15.Cd Deposition by sputtering
81.15.Ef Vacuum deposition
81.15.Fg Laser deposition
81.15.Gh Chemical vapor deposition (including plasma-enhanced CVD, MOCVD, etc.) (for chemistry of MOCVD, see 82.33.1a in physical chemistry and chemical physics)
81.15.Hi Molecular, atomic, ion, and chemical beam epitaxy
81.15.Jj Ion and electron beam-assisted deposition; ion plating (see also 52.77.Dq Plasma-based ion implantation and deposition in physics of plasmas)
81.15.Kk Vapor phase epitaxy; growth from vapor phase

81.15.Lm Liquid phase epitaxy; deposition from liquid phases (melts, solutions, and surface layers on liquids)
81.15.Np Solid phase epitaxy; growth from solid phases
81.15.Pq Electrodeposition, electroplating
81.15.Rs Spray coating techniques

81.16. Methods of nanofabrication and processing (for femtosecond probing of semiconductor nanostructures, see 82.53.Mj in physical chemistry and chemical physics)

81.16.Bc Chemical synthesis methods
81.16.Dn Self-assembly
81.16.Fg Supramolecular and biochemical assembly
81.16.Hc Catalytic methods
81.16.Mk Laser-assisted deposition
81.16.Nd Nanolithography
81.16.Pr Nanooxidation (see also 82.37.Np Single molecule reaction kinetics in physical chemistry and chemical physics)
81.16.Rf Nanoscale pattern formation
81.16.Ta Atom manipulation (see also 82.37.Gk STM and AFM manipulation of a single-molecule in physical chemistry, 37.10.Gh Atom traps and guides; 37.10.Pq Trapping of molecules; 87.80.Nj Single-molecule techniques in biological physics; 82.37.Rs Single-molecule manipulation of proteins and other biological molecules in physical chemistry)

81.20. Methods of materials synthesis and materials processing (for ion implantation and doping, see 61.72.U-)

- Crystal growth, see 81.10. –h
- Film deposition, film growth, and epitaxy, see 81.15. –z

81.20.Ev Powder processing: powder metallurgy, compaction, sintering, mechanical alloying, and granulation
81.20.Fw Sol–gel processing, precipitation
81.20.Hy Forming; molding, extrusion etc.
81.20.Ka Chemical synthesis; combustion synthesis (for electrochemical synthesis, see 82.45.Aa)

- Chemical vapor deposition, see 81.15.Gh
81.20.Rg Aerosols in materials synthesis and processing
81.20.Vj Joining; welding
81.20.Wk Machining, milling
81.20.Ym Purification
81.30.—t Phase diagrams and microstructures developed by solidification and solid–solid phase transformations (see also 64.70.K – Solid–solid transitions)
81.30.Bx Phase diagrams of metals and alloys
81.30.Dz Phase diagrams of other materials (for phase diagrams of superconductors, see 74.25.Dw)
81.30.Fb Solidification
81.30.Hd Constant-composition solid–solid phase transformations: polymorphic, massive, and order–disorder
81.30.Kf Martensitic transformations
81.30.Mh Solid-phase precipitation (see also 64.75. – g Phase equilibria)
81.40.—z Treatment of materials and its effects on microstructure and properties
81.40.Cd Solid solution hardening, precipitation hardening, and dispersion hardening; aging (see also 64.75.Ns Phase separation and segregation in solid solutions)
81.40.Ef Cold working, work hardening; annealing, post-deformation annealing, quenching, tempering, recovery, and crystallization
81.40.Gh Other heat and thermomechanical treatments
81.40.Jj Elasticity and anelasticity, stress-strain relations
81.40.Lm Deformation, plasticity, and creep (see also 83.50. – v Deformation and flow in rheology)
81.40.Np Fatigue, corrosion fatigue, embrittlement, cracking, fracture, and failure (see also 62.20.M – Structural failure of materials)
81.40.Pq Friction, lubrication, and wear
81.40.Rs Electrical and magnetic properties (related to treatment conditions)
81.40.Tv Optical and dielectric properties (related to treatment conditions)
81.40.Ww Pressure treatment (see also 62.50. – p High-pressure effects in solids and liquids)
81.40.Wx Radiation treatment (particle and electromagnetic) (see also 61.80. – x Physical radiation effects, radiation damage)
81.65.—b Surface treatments (see also 85.40. – e Microelectronics: LSI, VLSI, ULSI; integrated circuit fabrication technology)
81.65.Cf Surface cleaning, etching, patterning (see also 52.77.Bn Etching and cleaning in physics of plasmas)
81.65.Kn Corrosion protection (see also 82.45.Bh Corrosion and passivation in electrochemistry)
81.65.Lp Surface hardening: nitridation, carburization, carbonitridation
81.65.Mq Oxidation
81.65.Ps Polishing, grinding, surface finishing
81.65.Rv Passivation (see also 82.45.Bh Corrosion and passivation in electrochemistry)
81.65.Tx Gettering
81.70.—q Methods of materials testing and analysis (for specific chemical analysis methods, see 82.80. – d)
81.70.Bt Mechanical testing, impact tests, static and dynamic loads
81.70.Cv Nondestructive testing: ultrasonic testing, photoacoustic testing
81.70.Ex Nondestructive testing: electromagnetic testing, eddy-current testing
81.70.Fy Nondestructive testing: optical methods
81.70.Ha Testing in microgravity environments
81.70.Jb Chemical composition analysis, chemical depth and dopant profiling
81.70.Pg Thermal analysis, differential thermal analysis (DTA), differential thermogravimetric analysis
81.70.Tx Computed tomography
81.90.+c Other topics in materials science (restricted to new topics in section 81)

82. Physical chemistry and chemical physics

→ Electronic structure theory of atoms and molecules, see 33.15. – p
→ Electronic structure theory of condensed matter, see section 71
→ Electronic structure theory for biomolecules, see 87.10. – e
→ Electronic structure of macromolecules and polymer molecules, see 36.20.Kd
→ Geochemistry, see 91.67. – y
→ Chemistry of the ocean, see 92.20.Cn
→ Chemistry of fresh water, see 92.40.Bc
→ Ion chemistry of the atmosphere, see 92.60.Ls
→ Chemical reactions in scattering of atoms and molecules, see 34.50.Lf

82.20.—w Chemical kinetics and dynamics
82.20.Bc State selected dynamics and product distribution
82.20.Db Transition state theory and statistical theories of rate constants
82.20.Ej Quantum theory of reaction cross section
82.20.Fd Collision theories; trajectory cross sections
82.20.Gk Electronically non-adiabatic reactions
82.20.Hf Product distribution (for state selected dynamics and product distribution, see 82.20.Bc)
82.20.Kh Potential energy surfaces for chemical reactions (for potential energy surfaces for collisions, see 34.20. – b in atomic and molecular collisions and interactions)
82.20.Ln Semiclasical theory of reactions and/or energy transfer
82.20.Nk Classical theories of reactions and/or energy transfer
82.20.Pm Rate constants, reaction cross sections, and activation energies
82.20.Rp State to state energy transfer (see also 31.70.Hq Time-dependent phenomena—in atomic and molecular physics)
82.20.Sb Correlation function theory of rate constants and its applications
82.20.Tr Kinetic isotope effects including muonium
82.20.Uv Stochastic theories of rate constants
82.20.Wt Computational modeling; simulation
82.20.Xr Quantum effects in rate constants (tunneling, resonances, etc.)
82.20.Yn Solvent effects on reactivity
82.30.—b Specific chemical reactions; reaction mechanisms
82.30.Cf Atom and radical reactions; chain reactions; molecule-molecule reactions
82.30.Fi Ion–molecule, ion–ion, and charge-transfer reactions (see also 34.70. + e Charge transfer in atomic and molecular collisions)
→ Charge transfer in enzymes, see 82.39.Jn and 87.15.R –
82.30.Gg Positronium chemistry (see also 36.10.Dr Positronium in atomic and molecular physics; 78.70.Bj Positron annihilation in interactions of particles and radiation with matter)
82.30.Hk Chemical exchanges (substitution, atom transfer, abstraction, disproportionation, and group exchange)
82.30.Lp Decomposition reactions (pyrolysis, dissociation, and fragmentation)
82.30.Nr Association, addition, insertion, cluster formation
82.30.Qt Isomerization and rearrangement
82.30.Rs Hydrogen bonding, hydrophilic effects
82.30.Vy Homogeneous catalysis in solution,
polymers and zeolites (for heterogeneous catalysis in zeolites, see 82.75.Qf)

- - - - Enzyme kinetics, see 82.39.Fk and 87.15.R-

- - - - Protein folding dynamics, see 87.15.Hm

82.33.–z Reactions in various media
82.33.De Reactions in supercritical fluids
82.33.Fg Reactions in clusters (see also 36.40.Jn Reactivity of clusters in atomic and molecular physics)
82.33.Hk Reactions on clusters
82.33.Jx Reactions in zeolites
82.33.Ln Reactions in sol gels, aerogels, porous media
82.33.Nq Reactions in micelles
82.33.Pt Solid state chemistry

- - - - Reactions in complex biological systems, see 82.39.Rt and 87.15.R-

82.33.Tb Atmospheric chemistry (see also 92.60.H-
82.33.Vx Reactions in flames, combustion, and explosions
82.33.Xj Plasma reactions (including flowing afterglow and electric discharges)
82.33.Ya Chemistry of MOCVD and other vapor deposition methods (for methods of vapor deposition of films and coatings, see 81.15.Gh, Kk in materials science)

82.35.–x Polymers: properties; reactions; polymerization (for polymers in electrochemistry, see 82.45.Wx)
82.35.Cd Conducting polymers
82.35.Ej Nonlinear optics with polymers (see also 42.65.–k in nonlinear optics)
82.35.Gh Polymers on surfaces; adhesion (see also 68.35.Np Adhesion in surfaces and interfaces)
82.35.Jk Copolymers, phase transitions, structure
82.35.Lr Physical properties of polymers
82.35.Np Nanoparticles in polymers (see also 81.07.–b Nanoscale materials and structures: fabrication and characterization)
82.35.Pq Biopolymers, biopolymerization (see also 87.15.rp Polymerization in biological and medical physics)
82.35.Rs Polyelectrolytes

- - - - Protein properties, folding, see 87.15.Cc and 87.15.hm

- - - - Enzymes, see 82.39.Fk and 87.14.ej

- - - - DNA/RNA, see 82.39.Pj and 87.14.gk, gn

82.37.–j Single molecule kinetics
82.37.Gk STM and AFM manipulations of a single molecule (for atom manipulation see 37.10.Gh, Pg in atomic and molecular physics; see also 81.16.Ta Atom manipulation in methods of nanofabrication and processing; 87.80.Nj Single-molecule techniques in biological physics)

82.37.Np Single molecule reaction kinetics, dissociation, etc.
82.37.Rs Single molecule manipulation of proteins and other biological molecules
82.37.Vb Single molecule photochemistry

82.39.–k Chemical kinetics in biological systems (see also 87.15.R – Reactions and kinetics in biological and medical physics, and 82.45.Tv Bioelectrochemistry)

82.39.Fk Enzyme kinetics (see also 87.14.ej Enzymes in biological physics)
82.39.Jn Charge (electron, proton) transfer in biological systems

- - - - Protein folding, see 87.15.Cc and 87.15.hm

82.39.Pj Nucleic acids, DNA and RNA bases
82.39.Rt Reactions in complex biological systems (see also 87.18.–h Biological complexity)
82.39.Wj Ion exchange, dialysis, osmosis, electro-osmosis, membrane processes

82.40.–g Chemical kinetics and reactions: special regimes and techniques

- - - - Chemically reactive flows, see 47.70.Fw

82.40.Bj Oscillations, chaos, and bifurcations
82.40.Ck Pattern formation in reactions with diffusion, flow and heat transfer (see also 47.54.–r Pattern selection; pattern formation and 47.32.C – Vortex dynamics in fluid dynamics)
82.40.Fp Shock wave initiated reactions, high-pressure chemistry (see also 47.40.Nm Shock wave interactions and shock effects in fluid dynamics, and 62.50.Ej Shock wave effects in solids and liquids)
82.40.Np Temporal and spatial patterns in surface reactions
82.40.Qt Complex chemical systems (for complex biological systems, see 82.39.Rt in physical chemistry; 87.18.–h in biological physics)

82.45.–h Electrochemistry and electrophoresis

82.45.Aa Electrochemical synthesis (see also 81.16.Be Chemical synthesis methods in nanofabrication and 81.20.Ka Chemical synthesis; combustion synthesis in materials science)
82.45.Bb Corrosion and passivation (see also 81.65.Kn Corrosion protection and 81.65.Rv Passivation in surface treatments)
82.45.Cc Anodic films
82.45.Fk Electrodes
82.45.Gj Electrolytes (for polyelectrolytes, see 82.35.Rs and 82.45.Wx; see also 66.30.H – Self-diffusion and ionic conduction in nonmetals)
82.45.Hk Electrolysis
82.45.Jn Surface structure, reactivity and catalysis (see also 82.65.–r Surface and interface chemistry; heterogeneous catalysis at surfaces)
82.45.Mp Thin layers, films, monolayers, membranes (for anodic films, see 82.45.Cc; for surface double layers, see 73.30.–y in electronic structure of surfaces)
82.45.Qr Electrodissolution and electrodeposition (see also 81.15.Pg Electrodeposition, electroplating in materials science)
82.45.Rr Electroanalytical chemistry (see also 82.80.Fk Electrochemical methods in chemical analysis and related physical methods of analysis)
82.45.Tv Bioelectrochemistry (see also 82.39.–k Chemical kinetics in biological systems; 87.15.Ti Electrophoresis in biological physics)
82.45.Un Dielectric materials in electrochemistry (see also 77.84.–s Dielectric, piezoelectric, ferroelectric, and antiferroelectric materials)
82.45.Vp Semiconductor materials in electrochemistry (see also 81.05.Cy, Dy, Ea, Gc, Hd in specific materials)
82.45.Wx Polymers and organic materials in electrochemistry (see also 82.35.–k Polymers: properties; reactions; polymerization)
82.45.Xy Ceramics in electrochemistry (see also 81.05.Je, Mh in specific materials)
82.45.Yz Nanomaterials in electrochemistry (for nanofabrication, see 81.16.–c in materials science)
82.47.–a Applied electrochemistry
82.47.Aa Lithium-ion batteries
82.47.Cb Lead-acid, nickel-metal hydride and other batteries (for lithium-ion batteries, see 82.47.Aa)
82.47.Ed Solid-oxide fuel cells (SOFC)
82.47.Gh Proton exchange membrane (PEM) fuel cells
82.47.Jk Photoelectrochemical cells, photovoltaic and other hybrid electrochemical energy storage devices (see also 84.60.Jt Photoelectric conversion, solar cells and arrays)
82.47.Lh Molten-carbonate fuel cells (MCFC)
82.47.Nj Polymer-electrolyte fuel cells (PEFC)
82.47.Pm Phosphoric-acid fuel cells (PAFC); other fuel cells
82.47.Rs Electrochemical sensors
82.47.Tp Electrochemical displays
82.47.Uv Electrochemical capacitors; supercapacitors
82.47.Wx Electrochemical engineering

82.50.–m Photochemistry (for single molecule photochemistry, see 82.37.Vb)
---- Optical spectroscopy in atomic and molecular physics, see 32.30.–r and 33.20.–r
---- Optical spectroscopy in condensed matter, see 78.35.–c, 78.40.–q, and 78.47.–p
82.50.Bc Processes caused by infrared radiation
82.50.Hp Processes caused by visible and UV light
82.50.Kx Processes caused by X-rays or γ-rays
82.50.Nd Processes caused by X-rays or X-rays
82.50.Pt Multiphoton processes
---- Potential energy surfaces for excited electronic states, see 31.50.Df
---- Surface crossings, non-adiabatic couplings, see 31.50.Gh

82.53.—k Femtochemistry [see also 78.47.Jr Ultrafast pump/probe spectroscopy (<1 psec) in condensed matter; 42.65.Re Ultrafast processes; optical generation and pulse compression in nonlinear optics]
82.53.Eb Pump probe studies of photodissociation
82.53.Hn Pump probe experiments with bound states
82.53.Kp Coherent spectroscopy of atoms and molecules
82.53.Mj Femtosecond probing of semiconductor nanostructures (see also 81.16.–c Methods of nanofabrication and processing)
82.53.Ps Femtosecond probing of biological molecules
82.53.St Femtochemistry of adsorbed molecules (for adsorbate structure, see 68.43.Bc, Fq in chemisorption/physisorption: adsorbates on surfaces)
82.53.Uv Femtosecond probes of molecules in liquids
82.53.Xa Femtosecond probes of molecules in solids and of molecular solids

82.55. –b Nuclear magnetic resonance (see also 33.25.–k Nuclear resonance and relaxation in atomic and molecular physics; 76.60.–k Nuclear magnetic resonance and relaxation; 76.70.–r Magnetic double resonances and cross effects in condensed matter)
82.56.Dj High resolution NMR
82.56.Fk Multidimensional NMR
82.56.Hg Multinuclear NMR
82.56.Jn Pulse sequences in NMR
82.56.Na Relaxation
82.56.Pr NMR of biomolecules
82.56.Ub Structure determination with NMR
---- ENDOR, see 76.70.Dx and 33.40.–f
---- NMR imaging, see 76.60.Pc and 87.61.–c

82.60.–s Chemical thermodynamics
82.60.Cx Enthalpies of combustion, reaction, and formation
82.60.Fa Heat capacities and heats of phase transitions
82.60.Hc Chemical equilibria and equilibrium constants
82.60.Lf Thermodynamics of solutions
82.60.Nh Thermodynamics of nucleation (see also 64.60.Q–k Nucleation—in equations of state, phase equilibria and phase transitions)
82.60.Qr Thermodynamics of nanoparticles
---- Irreversible thermodynamics, nonequilibrium thermodynamics, see 05.70.Ln

82.65.+r Surface and interface chemistry; heterogeneous catalysis at surfaces (for temporal and spatial patterns in surface reactions, see 82.40.Np; see also 82.45.Jn Surface structure, reactivity and catalysis in electrochemistry)
---- Chemisorption/photophysics: adsorbates on surfaces, see 68.43.–h

82.70.–y Disperse systems; complex fluids (see also 82.33.–c Reactions in various media; for quantum optical phenomena in dispersive media, see 42.50.Nu)
82.70.Dd Colloids
82.70.Gg Gels and sols
82.70.Kj Emulsions and suspensions

82.70.Rr Aerosols and foams
82.70.Uv Surfactants, micellar solutions, vesicles, lamellae, amphiphilic systems, (hydrophilic and hydrophobic interactions) (see also 82.30.Rs Hydrogen bonding, hydrophilic effects in specific chemical reactions)
---- Nanoscale materials and structures, see 81.07.–b and 61.46.–w
---- Preparation and assembly of nanostructures, see 81.16.–c
---- Structural transitions in nanoscale materials, see 64.70.Nd
---- Spectroscopy of nanostructures, see 78.67.–n

82.75.–z Molecular sieves, zeolites, clathrates, and other complex solids
82.75.Fq Synthesis, structure determination, structure modeling
82.75.Jn Measurements and modeling of molecule migration in zeolites
82.75.Mj Measurements and simulation of properties (optical, structural) of molecules in zeolites
82.75.Qt Mechanism and kinetics of catalysis in zeolites (measurements or simulations)
82.75.Vx Clusters in zeolites
# 83. Rheology

(see also section 47 Fluid dynamics; for rheology of the Earth, see 91.32. —m; see also 87.19.7h Fluid transport and rheology in biological physics)

### 83.10. —y Fundamentals and theoretical
83.10.Bb Kinematics of deformation and flow
   · · · Non-Newtonian fluid flows, see 47.50. —d
83.10.Ff Continuum mechanics (see also section 46 Continuum mechanics of solids)
83.10.Gr Constitutive relations
83.10.Kn Reptation and tube theories
83.10.Mj Molecular dynamics, Brownian dynamics
83.10.Pp Particle dynamics
83.10.Rs Computer simulation of molecular and particle dynamics
83.10.Tv Structural and phase changes

### 83.30. —v Deformation and flow
83.30.Ax Steady shear flows, viscometric flow
83.30.Ha Flow in channels (see also 47.60.Dx Flows in ducts and channels in fluid dynamics)
83.30.Jf Extensional flow and combined shear and extension
83.30.Lh Slip boundary effects (interfacial and free surface flows) (see also 47.45.Qx Slip flows and accommodation in fluid dynamics)
83.30.Rp Wall slip and apparent slip
83.30.Uv Material processing (extension, molding, etc.)
83.30.Xa Mixing and blending

### 83.60. —a Material behavior
83.60.Bc Linear viscoelasticity
83.60.Df Nonlinear viscoelasticity
83.60.Fg Shear rate dependent viscosity
83.60.Hc Normal stress differences and their effects (e.g. rod climbing)
83.60.Jk Extrudate swell
83.60.La Viscoplasticity; yield stress
83.60.Np Effects of electric and magnetic fields
83.60.Pq Time-dependent structure (thixotropy, rheopexy)

### 83.30. —c Techniques and apparatus
83.35.Cg Rheological measurements—rheometry
83.35.Ei Optical methods; rheo-optics
83.35.Fg NMR/magnetic resonance imaging (see also 76.60.Pc NMR imaging in condensed matter)
83.35.Hf X-ray and neutron scattering
83.35.Jn Viscosity measurements
83.35.Lq Normal stress difference measurements
83.35.Ns Data analysis (interconversion of data computation of relaxation and retardation spectra; time-temperature superposition, etc.)
   · · · Computational fluid dynamics, see 47.11. —j
83.35.Rx Extensional flow measurement
83.35.St Stress relaxation
83.35.Tz Creep and/or creep recoil

### 83.80. —k Material type (see also 82.70. —y Disperse systems; complex fluids and 82.35. —x Polymers: properties; reactions; polymerization in physical chemistry and chemical physics)
83.80.Ab Solids: e.g., composites, glasses, semicrystalline polymers
83.80.Fg Granular solids
83.80.Gv Electro- and magnetorheological fluids
83.80.Hj Suspensions, dispersions, pastes, slurries, colloids
83.80.Iz Emulsions and foams
83.80.Jx Reacting systems: thermostetting polymers, chemorheology, rheokinetics
83.80.Kn Physical gels and microgels
83.80.Lz Physiological materials (e.g. blood, collagen, etc.)
83.80.Mc Other natural materials (e.g. wood and other vegetable materials)
83.80.Nb Geological materials: Earth, magma, ice, rocks, etc.
83.80.Qr Surfactant and micellar systems, associated polymers
83.80.Rs Polymer solutions
83.80.Sg Polymer melts
83.80.Tc Polymer blends
83.80.Uv Block copolymers
83.80.Va Elastomeric polymers
83.80.Wx Filled elastomers
83.80.Xz Liquid crystals: nematic, cholesteric, smectic, discotic, etc.
83.80.Ya Processed food

### 83.85. —b Small amplitude oscillatory shear
83.85.Ns Data analysis
83.85.Tz Creep and/or creep recoil

### 84. Electronics; radiowave and microwave technology; direct energy conversion and storage

#### 84.30. —r Electronic circuits (for integrated circuits, see 85.40. —e; for microwave circuits, see 84.40.Dc)
84.30.Bv Circuit theory
84.30.Jc Power electronics; power supply circuits (see also 84.70. —p High-current and high-voltage technology; for superconducting high-power technology, see 84.71. —b)
84.30.Le Amplifiers
84.30.Ng Oscillators, pulse generators, and function generators
84.30.Qi Modulators, pulse generators, and function generators
84.30.Tr Inductors; transformers; magnetic switching devices
84.30.Vn Filters

#### 84.32. —y Passive circuit components (see also 07.50. —e Electrical and electronic instruments, and components)
84.32.Dd Connectors, relays, and switches
84.32.Ff Conductors, resistors (including thermistors, varistors, and photoresistors)
84.32.Hh Inductors and coils; wiring
84.32.Tt Capacitors (for electrochemical capacitors and supercapacitors, see 82.47.Uv)
84.32.Vv Fuses

#### 84.35. +i Neural networks (for optical neural networks, see 42.79.Ta; see also 07.05.Mh Neural networks, fuzzy logic, artificial intelligence in computers in experimental physics; 87.18.Sn in biological complexity)

#### 84.37. +q Measurements in electric variables (including voltage, current, resistance, capacitance, inductance, impedance, and admittance, etc.)
84.40. —x Radiowave and microwave (including millimeter wave) technology
   · · · Microwave, submillimeter wave, and radiowave receivers and detectors, see 07.57.Kp
   · · · Microwave and radiowave spectrometers, see 07.57.Pt
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and CCD detectors) (for superconducting infrared detectors, see 85.25.Pb; for superconducting optical, x-ray and γ-ray detectors, see 85.25.Oj; see also 07.57.Kp in instruments)

85.60.Ha Photomultipliers; phototubes and photocathodes
85.60.Jb Light-emitting devices
85.60.Pg Display systems (for field emission display, see 85.45.Fd, for optical display devices, see 42.79.Kr; for electrochemical displays, see 82.47.Tp; see also 07.07.Hj Display and recording equipment, oscilloscopes, TV cameras, etc.)

85.65.+h Molecular electronic devices
85.70.—w Magnetic devices
     · · · Molecular magnets, see 75.50.Xs
     · · · Magnets, see 07.55_Db
     · · · Superconducting magnets and magnetic levitation devices, see 84.71.Ba
     · · · Beam bending magnets, see 41.85_Lx
85.70.Ay Magnetic device characterization, design, and modeling
85.70.Ec Magnetostriective, magnetoooustic, and magnetostatic devices (for magnetostriective transducers, see 43.38.Ct—in Acoustics Appendix)
     · · · Magnetic recording materials, see 75.50.Ss
85.70.Ge Ferrite and garnet devices
85.70.Kh Magnetic thin film devices: magnetic heads (magnetoresistive, inductive, etc.); domain-motion devices, etc.
85.70.Li Other magnetic recording and storage devices (including tapes, disks, and drums)
85.70.Rp Magnetic levitation, propulsion and control devices (for superconducting magnetic levitation devices, see 84.71.Ba)
85.70.Sq Magnetooptic devices
85.75.—d Magnetoelectronics; spintronics: devices exploiting spin polarized transport or integrated magnetic fields
85.75.Bb Magnetic memory using giant magnetoresistance
85.75.Dd Magnetic memory using magnetic tunnel junctions
85.75.FF Reprogrammable magnetic logic
85.75.Hh Spin polarized field effect transistors
85.75.MM Spin polarized resonant tunnel junctions
85.75.Nn Hybrid Hall devices
85.75.Ss Magnetic field sensors using spin polarized transport
85.80.—b Thermoelectromagnetic and other devices (for acoustoelectric devices, see 43.38.—p in Acoustics Appendix; for electrochemical devices, see 82.47.—a)
85.80.Fi Thermoelectric devices
85.80.Jm Magnetoelectric devices
85.80.Lp Magnetothermal devices
85.85.+j Micro- and nanoelectromechanical systems (MEMS/NEMS) and devices
85.90.+h Other topics in electronic and magnetic devices and microelectronics (restricted to new topics in section 85)

87. Biological and medical physics
87.10.—e General theory and mathematical aspects
87.10.Ca Analytical theories
87.10.Ed Ordinary differential equations, partial differential equations (PDE), integrodifferential models
87.10.Hk Lattice models
87.10.Kn Finite element calculations
87.10.Mn Stochastic modeling
87.10.Pq Elasticity theory
87.10.Rt Monte Carlo simulations
87.10.Tf Molecular dynamics simulation
87.10.Vg Biological information
87.14.—g Biomolecules: types
87.14.Cc Lipids
87.14.Df Carbohydrates
87.14.E— Proteins
87.14.ef Peptides
87.14.ej Enzymes
87.14.em Fibrials (amyloids, collagen, etc.)
87.14.ep Membrane proteins
87.14.et Generic models (lattice, HP, etc.)
87.14.G— Nucleic acids
87.14.gf Nucleotides
87.14.gk DNA
87.14.gn RNA
87.14.Lk Hormones
87.14.Pq Vitamins
87.15.—v Biomolecules: structure and physical properties
87.15.A— Theory, modeling, and computer simulation
87.15.ad Analytical theories
87.15.ag Quantum calculations
87.15.ak Monte Carlo simulations
87.15.ap Molecular dynamics simulation
87.15.B— Structure of biomolecules
87.15.bd Secondary structure
87.15.bg Tertiary structure
87.15 bk Structure of aggregates
87.15.Cc Folding: thermodynamics, statistical mechanics, models, and pathways

(see also 87.15.hm Folding dynamics)
87.15.Fh Bonding; mechanisms of bond breakage
87.15.H— Dynamics of biomolecules
87.15.hg Dynamics of intermolecular interactions
87.15.hj Transport dynamics
87.15.hm Folding dynamics
87.15.hp Conformational changes
87.15.ht Ultrafast dynamics; charge transfer
87.15.k— Molecular interactions; membrane-protein interactions
87.15. kj Protein-polynucleotide interactions
87.15.km Protein-protein interactions
87.15.kp Protein-ligand interactions
87.15.kr Protein-solvent interactions
87.15. kt Protein-membrane interactions
87.15.La Mechanical properties
87.15.M— Spectra of biomolecules
87.15.mk Photodissociation
87.15.mn Photoinization
87.15.mq Luminescence
87.15.N— Properties of solutions of macromolecules
87.15.np Dissolution
87.15.nr Aggregation
87.15.mt Crystallization
87.15.Pc Electronic and electrical properties
87.15.Qt Sequence analysis
87.15.R— Reactions and kinetics (see also 82.39.—k Chemical kinetics in biological systems in physical chemistry)
87.15.rp Polymerization (see also 82.35.Pq Biopolymers, biopolymerization in physical chemistry)
87.15.rs Dissociation
87.15.Tt Electrophoresis (see also 82.45.—h Electrochemistry and electrophoresis)
87.15.Vv Diffusion
87.15.Ya Fluctuations
87.15.Zg Phase transitions
87.16.—b Subcellular structure and processes
87.16.A— Theory, modeling, and simulations
87.16.ad Analytical theories
87.16.af Monte Carlo calculations
87.16.ai Lattice models
87.16.d— Membranes, bilayers, and vesicles
87.16.dj Dynamics and fluctuations
87.16.dm Mechanical properties and rheology
87.16.dp Transport, including channels, pores, and lateral diffusion
87.16.dr Assembly and interactions
87.16.dt Structure, static correlations, domains, and rafts
87.16.Gj Cell walls
87.16.Ka Filaments, microtubules, their networks, and supramolecular assemblies
87.16.Ln Cytoskeleton
87.16.Mq Morphology of nerve cells
87.16.Nn Motor proteins (myosin, kinesin dynein)
87.16.Qp Pseudopods, lamellipods, cilia, and flagella
87.16.Sr Chromosomes, histones
87.16.Tb Mitochondria and other organelles
87.16.Vy Ion channels
87.16.Wd Intracellular trafficking
87.16.Xa Signal transduction and intracellular signaling
87.16.Yc Regulatory genetic and chemical networks
87.16.Zg Nuclear morphology
87.17.–d Cell processes
87.17.Aa Modeling, computer simulation of cell processes
87.17.Ee Growth and division
87.17.Jj Cell locomotion, chemotaxis
87.17.Pq Morphogenesis
87.17.Rt Cell adhesion and cell mechanics
87.17.Uv Biotechnology of cell processes
87.18.–h Biological complexity (see also 82.39.Rt Reactions in complex biological systems in physical chemistry)
87.18.Cf Genetic switches and networks
87.18.Ed Cell aggregation
87.18.Fx Multicellular phenomena, biofilms
87.18.Gh Cell-cell communication; collective behavior of motile cells
87.18.Hf Spatiotemporal pattern formation in cellular populations
87.18.Mp Signal transduction networks
87.18.Nq Large-scale biological processes and integrative biophysics
87.18.Sn Neural networks and synaptic communication
87.18.Ti Noise in biological systems
87.18.Vf Systems biology
87.18.Wd Genomics
87.18.Xr Proteomics
87.18.Yt Circadian rhythms
87.19.–j Properties of higher organisms
87.19.Ff Muscles
87.19.Hh Cardiac dynamics
87.19.L– Neuroscience
87.19.Lb Action potential propagation and axons
87.19.Le Noise in the nervous system
87.19.Id Electrodynamics in the nervous system
87.19.Le EEG and MEG
87.19.Jg Synapses: chemical and electrical (gap junctions)
87.19.Jh Optical imaging of neuronal activity
87.19.Jl Neuronal network dynamics
87.19.Ik Glia
87.19.IL Models of single neurons and networks
87.19.Im Synchronization in the nervous system
87.19.In Oscillations and resonance
87.19.IO Information theory
87.19.Ip Pattern formation: activity and anatomic
87.19.Iq Neuronal wave propagation
87.19.Ir Control theory and feedback
87.19.Is Encoding, decoding, and transformation
87.19.IT Sensory systems: visual, auditory, tactile, taste, and olfaction
87.19.Iv Learning and memory
87.19.Iw Plasticity
87.19.Is Development and growth
87.19.Iy Energetics
87.19.Pp Biothermics and thermal processes in biology
87.19.R– Mechanical and electrical properties of tissues and organs
87.19.Rd Elastic properties
87.19.Rf Dielectric properties
87.19.Rh Fluid transport and rheology
87.19.Rj Contraction
87.19.Rm Structure
87.19.Rp Impulse propagation
87.19.Rs Movement
87.19.Ru Locomotion
87.19.R– Hemodynamics
87.19.Us Heart and lung dynamics
87.19.Uj Peripheral vascular dynamics
87.19.Um Blood-brain barrier
87.19.Ux Pneumodynamics, respiration
87.19.X– Diseases
87.19.Xb Bacterial diseases
87.19.Xd Viral diseases
87.19.Xe Parasitic diseases
87.19.Xg Fungal diseases
87.19.Xh Prion diseases
87.19.Xj Cancer
87.19.Xk Genetic diseases
87.19.Xm Epilepsy
87.19.Xn Musculoskeletal
87.19.Xp Motor system disease (Parkinson’s, etc.)
87.19.Xq Stroke
87.19.Xr Degenerative diseases (Alzheimer’s, ALS, etc.)
87.19.Xt Developmental diseases
87.19.Xu Gastrointestinal diseases
87.19.Xw Endocrine diseases
87.19.Xw Immune system diseases
87.23.–n Ecology and evolution
87.23.Cc Population dynamics and ecological pattern formation
87.23.Ce Dynamics of social systems
87.23.Kg Dynamics of evolution
87.50.–a Effects of electromagnetic and acoustic fields on biological systems
87.50.C– Static and low-frequency electric and magnetic fields effects
87.50.cf Biophysical mechanisms of interaction
87.50.ch Electrophoresis/dielectrophoresis and other mechanical effects (see also 87.15.Ti Electrophoresis)
87.50.ci Electroproporation/membrane effects
87.50.cm Dosimetry/exposure assessment
87.50.ct Therapeutic applications
87.50.S– Radiofrequency/microwave fields effects
87.50.sg Biophysical mechanisms of interaction
87.50.up Dosimetry/exposure assessment
87.50.xe Therapeutic applications
87.50.xf Optical/infrared radiation effects
87.50.xw Biophysical mechanisms of interaction
87.50.wj Dosimetry/exposure assessment
87.50.wp Therapeutic applications
87.50.Y– Biological effects of acoustic and ultrasonic energy
87.50.yg Biophysical mechanisms of interaction
87.50.yk Dosimetry/exposure assessment
87.50.yt Therapeutic applications
87.53.–j Effects of ionizing radiation on biological systems
87.53.Ay Biophysical mechanisms of interaction
87.53.Bn Dosimetry/exposure assessment
87.53.Jw Therapeutic applications, including brachytherapy
87.53.Kn Conformal radiation treatment
87.53.Ly Stereotactic radiosurgery
87.55.–x Treatment strategy
87.55.D– Treatment planning
87.55.de Optimization
87.55.dh Tissue response
87.85.Qr Nanotechnologies-design
87.85.Rs Nanotechnologies-applications
87.85.St Robotics
87.85.Tu Modeling biomedical systems
87.85.Uv Micromanipulators
87.85.Va Micromachining
87.85.Wc Neural engineering (for neural prosthetics, see 87.85.E−)
87.85.Xd Dynamical, regulatory, and integrative biology
87.90.+y Other topics in biological and medical physics (restricted to new topics in section 87)

89. Other areas of applied and interdisciplinary physics
89.20.+a Interdisciplinary applications of physics
89.20.Bb Industrial and technological research and development
89.20.Dd Military technology and weapons systems; arms control
89.20.Ff Computer science and technology
89.20.Hh World Wide Web, Internet
89.20.Kk Engineering (for electrochemical engineering, see 82.47.Wx; for biomedical engineering, see 87.80.+y)
89.20.Mn Forensic science
89.30.+g Energy resources (see also 84.60.+h Direct energy conversion and storage)
89.30.Aa Fossil fuels
89.30.Cc Solar power
89.30.Ee Hydroelectric, hydrothermal, geothermal and wind power
89.30.Gg Nuclear fission power (for fission reactors, see 28.41.+i and 28.50.+k in nuclear physics)
89.30.Jj Nuclear fusion power (for fusion reactors, see 28.52.+s in nuclear physics)
89.40.+a Transportation
89.40.Bb Land transportation
89.40.Cc Water transportation
89.40.Dd Air transportation
89.60.+k Environmental studies (for ecology, see 87.23.+n)

89.60.+k Environmental studies (for ecology, see 87.23.+n)

89.60.Cc Environmental safety
89.60.Fe Environmental regulations
89.60.Gg Impact of natural and man-made disasters
89.65.+s Social and economic systems
89.65.Cd Demographic studies
89.65.Ef Social organizations; anthropology
89.65.Gh Economics; econophysics, financial markets, business and management
89.65.Lm Urban planning and construction
89.70.+a Information and communication theory (for telecommunications, see 84.40.Ua; for optical communications, see 42.79.Sz; for quantum information, see 03.67.+a; for applications to neuroscience, see 87.19.),(b)
89.70.Cf Entropy and other measures of information
89.70.Eg Computational complexity
89.70.Hj Communication complexity
89.70.Kn Channel capacity and error-correcting codes
89.75.+k Complex systems
89.75.Da Systems obeying scaling laws
89.75.Fb Structures and organization in complex systems
89.75.Hc Networks and genealogical trees
89.75.Kd Patterns
89.90.+n Other topics in areas of applied and interdisciplinary physics (restricted to new topics in section 89)
91. Solid Earth physics

91.10.---v Geodesy and gravity (see also 91.50.Ks Gravity and isostasy— in Marine geology and geophysics; 91.45.gh— in Geophysics Appendix)

91.10.By Mathematical geodesy; general theory

91.10.Da Cartography

91.10.Fc Space and satellite geodesy; applications of global positioning systems

91.10.Jf Topography; geometric observations

91.10.Kg Crustal movements and deformation

91.10.Lh Photogrammetry

91.10.Nj Rotational variations; polar wobble (see also 92.10.Iv Ocean influence of Earth’s rotation)

91.10.Op Gravity anomalies; time variable gravity

91.10.Pp Geodetic techniques; gravimetric measurements and instruments

91.10.Qm Harmonics of the gravity potential field; geopotential theory and determination

91.25.—r Geomagnetism and paleomagnetism; geoelectricity (see also 91.50.Iv Marine magnetics and electromagnetics)

91.25.Cw Origins and models of the magnetic field; dynamo theories

91.25.Dx Archeomagnetism

91.25.Ey Interactions between exterior sources and interior properties

91.25.F— Rock and mineral magnetism (see also 91.60.Pn Magnetic and electrical properties—in Physical properties of rocks and minerals)

91.25.fa Biogenic magnetic minerals

91.25.fd Environmental magnetism

91.25.G— Spatial variations in geomagnetism

91.25.ga Harmonics and anomalies

91.25.gj Attributed to seafloor spreading

91.25.Le Time variations in geomagnetism

91.25.Mf Magnetic field reversals: process and timescale

91.25.Ng Paleomagnetism

91.25.Ph Magnetostratigraphy

91.25.Qi Geoelectricity, electromagnetic induction, and telluric currents

91.30.—f Seismology

91.30.Ab Seismic sources (mechanisms, magnitude, moment frequency spectrum)

91.30.Cd Body wave propagation

91.30.Dk Seismicity (see also 91.45.gd—in Geophysics Appendix)

91.30.Fn Surface waves and free oscillations

91.30.Ga Subduction zones (see also 91.40.Rs—in Volcanology; 91.45.Hc—in Tectonophysics; 91.50.Wy—in Marine geology and geophysics; 91.67.fc—in Geophysics Appendix)

91.30.Hc Mid-ocean ridges (see also 91.40.St—in Volcanology; 91.50.Rt—in Marine geology and geophysics; 91.67.ffc—in Geophysics Appendix)

91.30.Iv Transform faults

91.30.Jk Tomography in seismology (see also 91.30.Pn Tomography of the Earth’s interior)

91.30.Mv Strong motions and shock waves

91.30.Nw Tsunamis (see also 92.10.hl—in Geophysics Appendix)

91.30.Px Earthquakes

91.30.Rz Nuclear explosion seismology

91.30.Tb Volcano seismology

91.30.Uv Core and mantle seismology

91.30.Vc Continental crust seismology

91.30.Wx Lithosphere seismology (see also 91.45.gf—in Geophysics Appendix)

91.30.Yc Oceanic crust seismology

91.30.Za Paleoseismology

91.32.—m Rheology of the Earth

91.32.Ac General aspects

91.32.De Crust and lithosphere

91.32.Gh Mantle

91.32.Jk Friction of fault zones

91.35.—x Earth’s interior structure and properties

91.35.Cb Models of interior structure

91.35.Dc Heat flow; geothermy (see also 91.50.Ln Heat flow (benthic)—in Marine geology and geophysics)

91.35.Ed Structure of the Earth’s interior below the upper mantle

91.35.Gf Structure of the crust and upper mantle

91.35.Lj Composition and state of the Earth’s interior (see also 91.67.gb—in Geophysics Appendix)

91.35.Pn Tomography of the Earth’s interior (see also 91.30.Jk Tomography in seismology)

91.40.—k Volcanology (see also 91.30.Tb Volcano seismology)

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95.55.Cs Ground-based ultraviolet, optical and infrared telescopes
95.55.Ev Solar instruments
95.55.Fw Space-based ultraviolet, optical, and infrared telescopes
95.55.Jz Radio telescopes and instrumentation; heterodyne receivers
95.55.Ka X- and γ-ray telescopes and instrumentation
95.55.Pe Lunar, planetary, and deep-space probes
95.55.Qf Photometric, polarimetric, and spectroscopic instrumentation
95.55.Rg Photodetectors and bolometers
95.55.Sh Auxiliary and recording instruments; clocks and frequency standards
95.55.Vj Neutrino, muon, pion, and other elementary particle detectors; cosmic ray detectors (see also 29.40.–n Radiation detectors—in Nuclear physics)
95.55.Ym Gravitational radiation detectors; mass spectrometers; and other instrumentation and techniques (see also 04.80.Nn Gravitational wave detectors and experiments in—General relativity and gravitation)
95.75.–z Observation and data reduction techniques; computer modeling and simulation
95.75.De Photography and photometry (including microlensing techniques)
95.75.Fg Spectroscopy and spectrophotometry
95.75.Hi Polarimetry
95.75.Kk Interferometry
95.75.Mn Image processing (including source extraction)
95.75.Pq Mathematical procedures and computer techniques
95.75.Qr Adaptive and segmented optics (see also 42.68.Wi Remote sensing; LIDAR and adaptive systems—in atmospheric optics)
95.75.Rs Remote observing techniques
95.75.Tv Digitization techniques
95.75.Wx Time series analysis, time variability
95.80.+p Astronomical catalogs, atlases, sky surveys, databases, retrieval systems, archives, etc.
95.85.–e Astronomical observations (additional primary heading(s) must be chosen with these entries to represent the astronomical objects and/or properties studied)
95.85.Bh Radio, microwave (>1 mm)
95.85.Fm Submillimeter (300 μm–1 mm)
95.85.Gn Far infrared (10–300 μm)
95.85.Hp Infrared (3–10 μm)
95.85.Jq Near infrared (0.75–3 μm)
95.85.Kr Visible (390–750 nm)
95.85.Ls Near ultraviolet (300–390 nm)
95.85.Mt Ultraviolet (10–300 nm)
95.85.Nv X-ray
95.85.Pw γ-ray
95.85.Ry Neutrino, muon, pion, and other elementary particles; cosmic rays
95.85.Sz Gravitational radiation, magnetic fields, and other observations
95.90.+v Historical astronomy and archaeoastronomy; and other topics in fundamental astronomy and astrophysics; instrumentation, techniques, and astronomical observations
96. Solar system; planetology
96.10.+i General; solar nebula; cosmogony
96.12.–a Planetology of solid surface planets (see also 96.15.–g Planetology of fluid planets; 96.30.Bc Comparative planetology)
96.12.Bc Origin and evolution
96.12.De Orbital and rotational dynamics
96.12.Fe Gravitational fields
96.12.Hg Magnetic field and magnetism
96.12.Jt Atmospheres
96.12.Kz Surfaces
96.12.Ma Composition
96.12.Pc Interiors
96.12.Qr Polar regions
96.12.St Heat flow
96.12.Uv Rings and dust
96.12.Wx Interactions with particles and fields
96.12.Xy Tectonics, volcanism
96.15.–g Planetology of fluid planets (see also 96.12.–a Planetology of solid surface planets; 96.30.Bc Comparative planetology)
96.15.Bc Origin and evolution
96.15.De Orbital and rotational dynamics
96.15.Ef Gravitational fields
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96.15.Pf Physical properties of materials
96.15.Qr Impact phenomena
96.15.St Tori and exospheres
96.15.Uv Rings and dust
96.15.Vx Interactions with particles and fields
96.15.Wx Tidal forces
96.15.Xy Polar regions
96.20.–n Moon
96.20.Br Origin and evolution
96.20.Dt Features, landmarks, mineralogy, and petrology
96.20.Jz Gravitational field, selenodesy, and magnetic fields
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96.25.–f Planetology of comets and small bodies
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96.25.Jz Ionospheres
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96.25.Pq Impact phenomena
96.25.Qr Interactions with solar wind plasma and fields
96.25.St Plasma and MHD instabilities
96.25.Tg Radiation and spectra
96.25.Vt Satellites
96.25.Xz Volcanism
96.30.–t Solar system objects
96.30.Bc Comparative planetology (see also 96.12.–a Planetology of solid surface planets; 96.15.–g Planetology of fluid planets)
96.30.Cw Comets (see also 96.25.–f Planetology of comets and small bodies)
96.30.Dz Mercury
96.30.Ea Venus
96.30.Gc Mars
96.30.Hf Martian satellites
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96.30.Ja Dwarf planet satellites
96.30.Kf Jupiter
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97.30.Dg Low-amplitude blue variables (alpha Cygni, beta Cephei, delta Scuti, delta Delphini, delta Canis Majoris, SX Phoeniciscus, etc.)

97.30.Eh Emission-line stars (Of, Be, Luminous Blue Variables, Wolf-Rayet, etc.)

97.30.Fi Chemically peculiar stars (Ap, Am, etc.)

97.30.Gj Cepheids (delta Cephei, W Virginis)

97.30.Hk Carbon stars, S stars, and related types (C, S, R, and N)

97.30.Jm Long-period variables (Miras) and semiregulars

97.30.Kn RR Lyrae stars; RV Tauri and PV Telescopi variables

97.30.Nr Flare stars (UV Ceti, RS Canum Venaticorum, FU Orionis, R Coronae Borealis variables, etc.)

97.30.Qt Novae, dwarf novae, recurrent novae, and other cataclysmic (eruptive) variables (see also 97.80.Gm, Jp Cataclysmic binaries and X-ray binaries)

97.30.Sw Unusual and peculiar variables

97.60.−s Late stages of stellar evolution (including black holes)

97.60.Bw Supernovae (see also 26.30.−k Nucleosynthesis in novae, supernovae, and other explosive stars; for nuclear physics aspects of supernovae evolution, see 26.50.−+z)

97.60.Gb Pulsars

97.60.Jd Neutron stars (see also 26.60.−c Nuclear matter aspects of neutron stars in—Nuclear physics)

97.60.Lf Black holes (see also 04.70.−s Physics of black holes in—General relativity and gravitation; for galactic black holes, see 98.35.Jk and 98.62.Jx)

97.80.−d Binary and multiple stars

97.80.Af Astrometric and interferometric binaries

97.80.Di Visual binaries

97.80.Fk Spectroscopic binaries; close binaries

97.80.Gm Cataclysmic binaries (novae, dwarf novae, recurrent novae, and nova-like objects); symbiotic stars (see also 97.30.Qt Novae)

97.80.Hn Eclipsing binaries

97.80.Jp X-ray binaries (see also 98.70.Qy X-ray sources and 97.60.Gb Pulsars)

97.80.Kq Multiple stars

97.82.−j Extrasolar planetary systems

97.82.Cp Photometric and spectroscopic detection; coronographic detection; interferometric detection

97.82.Dj Substellar companions; planets

97.82.Jw Infrared excess; debris disks; protoplanetary disks; exo-zodiacal dust

97.90.+j Other topics on stars (restricted to new topics in section 97)

98. Stellar systems; interstellar medium; galactic and extragalactic objects and systems; the Universe

98.10.−z Stellar dynamics and kinematics

98.20.−d Stellar clusters and associations

98.20.Af Associations of stars (OB, T, R) in the Milky Way

98.20.Bg Associations of stars (OB, T, R) in external galaxies

98.20.Di Open clusters in the Milky Way

98.20.Fk Open clusters in external galaxies

98.20.Gm Globular clusters in the Milky Way

98.20.Jp Globular clusters in external galaxies

98.30.−a Characteristics and properties of the Milky Way galaxy

98.30.Ac Origin, formation, evolution, age, and star formation

98.30.Bd Chemical composition and chemical evolution

98.30.Ce Mass and mass distribution

98.30.Df Kinematics, dynamics, and rotation

98.30.Eg Electric and magnetic fields

98.30.Gi Galactic halo

98.30.Hj Spiral arms and galactic disk

98.30.Jk Galactic center, bar, circumnuclear matter, and bulge (including black hole and distance measurements)

98.35.Ln Stellar content and populations; morphology and overall structure

98.35.Mp Infall and accretion

98.35.Nq Galactic winds and fountains

98.35.Pr Solar neighborhood

98.38.−j Interstellar medium (ISM) and nebulae in Milky Way

98.38.Am Physical properties (abundances, electron density, magnetic fields, scintillation, scattering, kinematics, dynamics, turbulence, etc.)

98.38.Bn Atomic, molecular, chemical, and grain processes

98.38.Cp Interstellar dust grains; diffuse emission; infrared cirrus

98.38.Dq Molecular clouds, H2 clouds, dense clouds, and dark clouds

98.38.Er Interstellar masers (for circumstellar masers, see 97.10.−a)

98.38.Fs Jets, outflows, and bipolar flows (for pre-main sequence objects, see 97.21.−+a)

98.38.Gt H I regions and 21-cm lines; diffuse, translucent, and high-velocity clouds

98.38.Hv H II regions; emission and reflection nebulae

98.38.Jw Infrared emission

98.38.Kx Intercloud medium (ICM); hot and highly ionized gas; bubbles

98.38.Ly Planetary nebulae (for nuclei of planetary nebulae, see also 97.20.Rp)

98.38.Mz Supernova remnants

98.52.−b Normal galaxies; extragalactic objects and systems (by type)

98.52.Cf Classification and classification systems

98.52.Eh Elliptical galaxies

98.52.Lp Lenticular (S0) galaxies

98.52.Nr Spiral galaxies

98.52.Sw Irregular and morphologically peculiar galaxies

98.52.Wz Dwarf galaxies (elliptical, irregular, and spheroidal)

98.54.−h Quasars; active or peculiar galaxies, objects, and systems

98.54.Aj Quasars (for quasar absorption and emission-line systems; Lyman forest, see 98.62.Ra)

98.54.Cm Active and peculiar galaxies and related systems (including BL Lacertae objects, blazars, Seyfert galaxies, Markarian galaxies, and active galactic nuclei)

98.54.Ep Starburst galaxies and infrared excess galaxies

98.54.Gr Radio galaxies

98.54.Kt Protoplanetary; protostellar galaxies

98.56.−p Local group; Magellanic Clouds

98.56.Ew Elliptical galaxies

98.56.Ne Spiral galaxies (M31 and M33)

98.56.Si Magellanic Clouds and other irregular galaxies

98.56.Tj Magellanic stream

98.56.Wm Dwarf galaxies (elliptical, irregular, and spheroidal)

98.58.−w Interstellar medium (ISM) and nebulae in external galaxies

98.58.Ay Physical properties (abundances, electron density, magnetic fields, scintillation, scattering, kinematics, dynamics, turbulence, etc.)

98.58.Bz Atomic, molecular, chemical, and grain processes

98.58.Ca Interstellar dust grains; diffuse emission; infrared cirrus

98.58.Db Molecular clouds, H2 clouds, dense clouds, and dark clouds

98.58.Ec Interstellar masers (for circumstellar masers, see 97.10.Fy)
98.58.Fd Jets, outflows and bipolar flows (for pre-main sequence objects, see 97.21. +a)

98.58.Ge H I regions and 21-cm lines; diffuse, translucent, and high-velocity clouds

98.58.Hf H II regions; emission and reflection nebulae

98.58.Jg Infrared emission

98.58.Kh Intercloud medium

98.58.Li Planetary nebulae (for nuclei of 98.58.Hf)

98.58.Mj Supernova remnants

98.58.Nk Tidal tails; H I shells

98.62.Ra Intergalactic matter; quasars

98.62.Qz Magnitudes and colors; luminosities

98.62.Py Distances, redshifts, radial velocities; spatial distribution of galaxies (for observational cosmology, see 98.80. Es)

98.62.Nx Jets and bursts; galactic winds and fountains

98.62.Od Energetic ions; cosmic rays

98.62.Qz Magnitudes and colors; luminosities

98.62.Ra Intergalactic matter; quasar absorption and emission-line systems; Lyman forest (for quasars, see 98.54.Aj; for inarchuster matter, see 98.65.Hb)

98.62.Sb Gravitational lenses and luminous arcs (see also 95.30.Sf Relativity and gravitational theory)

98.62.Tc Astrometry; identification

98.62.Ve Statistical and correlative studies of properties (luminosity and mass functions; mass-to-light ratio; Tully-Fisher relation, etc.)

98.65.Hb Intracluster matter; cooling and dark matter, see 95.35. +d; for dark energy, see 95.36. +x; for superclusters and large-scale structure of the Universe, see 98.65.Dx

98.70.Qc Quantum cosmology

98.70.Vc Background radiations

98.80.--k Cosmology (see also section 04 General relativity and gravitation; for origin and evolution of galaxies, see 98.62.Ai; for elementary particle and nuclear processes, see 95.30.Cq; for dark matter, see 95.35. +d; for dark energy, see 95.36. +x; for superclusters and large-scale structure of the Universe, see 98.65.Dx)

98.80.Bp Origin and formation of the Universe

98.80.Cq Particle-theory and field-theory models of the early Universe (including cosmic pancakes, cosmic strings, chaotic phenomena, inflationary universe, etc.)

98.80.Em Observational cosmology (including Hubble constant, distance scale, cosmological constant, early Universe, etc.)

98.80.Ft Origin, formation, and abundances of the elements (see also 26.35. +c Big Bang nucleosynthesis—in Nuclear astrophysics)

98.80.Jk Mathematical and relativistic aspects of cosmology

98.80.Qc Quantum cosmology (see also 04.60. +m Quantum gravity—in General relativity and gravitation)

98.90.+s Other topics on stellar systems; interstellar medium; galactic and extragalactic objects and systems; the Universe (restricted to new topics in section 98)

99.10.--x Errata and other corrections

99.10.Cd Errata

99.10.Fg Publisher’s note

99.10.Jk Corrected article

99.10.Ln Retraction

99.10.Np Editorial note

99.10.Qr Addenda
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94.05.Jq Spacecraft sheaths, wakes, and charging
94.05.Lk Turbulence
94.05.Pt Wave/wave, wave/particle interactions
94.05.Rx Experimental techniques and laboratory studies (see also 52.72. +v— in physics of plasmas)
94.05.S– Space weather
94.05.Sj Space radiation environment
94.05.sk Impacts on humans
94.05.sp Solar effects
94.05.sz Spacecraft sheaths, wakes, and charging
94.05.tq Impacts on technological systems
94.20.–y Physics of the ionosphere (for ionospheres of the planets, see 96.12.ji and 96.15.hk; for radiowave propagation, see 41.20.Jb—in electromagnetism)
94.20.Ac Auroral ionosphere (see also 92.60.bw Airglow and aurorae—in meteorology; 94.30.Aa Auroral phenomena in magnetosphere)
94.20.Bb Wave propagation (see also 94.30.Tz—in Physics of the magnetosphere)
94.20.Cf Ionospheric modeling and forecasting
94.20.D– Ionospheric structure, composition
94.20.de D region
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94.20.dj F region
94.20.dk Polar cap ionosphere
94.20.dl Topside region
94.20.dm Mid-latitude ionosphere
94.20.dt Equatorial ionosphere
94.20.dv Ion chemistry and composition; ionization mechanisms
94.20.Fg Plasma temperature and density
94.20.Qf Particle precipitation (see also 94.30.Ny—in Physics of the magnetosphere)
94.20.Qj Interactions between waves and particles, see 94.20.W–
94.20.Ss Electric fields; current system
94.20.Ti Ionospheric soundings; active experiments
94.20.Vv Ionospheric disturbances, irregularities, and storms
94.20.W– Ionospheric dynamics and interactions
94.20.wc Plasma motion; plasma convection; particle acceleration
94.20.wf Plasma waves and instabilities
94.20.wg Ionosphere/thermospheric interactions
94.20.wh Ionosphere/magnetosphere interactions
94.20.wj Wave/particle interactions
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94.20.wq Solar radiation and cosmic ray effects
94.20.ws Electromagnetic wave propagation
94.20.Xa Meteor-trail physics
94.30.–d Physics of the magnetosphere
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94.30.Bg Magnetospheric configuration and forecasting
94.30.C– Magnetospheric configuration and forecasting
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94.30.cf Outer magnetosphere
94.30.cg Magnetospheric cusp
94.30.ch Magnetoopause
94.30.cl Magnetotail
94.30.cp Magnetic reconnection
94.30.cq MHD waves, plasma waves, and instabilities
94.30.cs Plasma motion; plasma convection
94.30.ct Plasma sheet
94.30.cv Plasmasphere
94.30.cx Polar cap phenomena
94.30.Hn Energetic trapped particles
94.30.Kq Electric fields, field-aligned currents and current systems, and ring currents
94.30.Lr Magnetic storms, substorms
94.30.Ms Magnetic pulsations
94.30.Ny Energetic particle precipitation (see also 94.20.Qq—in Physics of the ionosphere)
94.30.Tz Electromagnetic wave propagation (see also 94.20.Bb—in Physics of the ionosphere)
94.30.V– Magnetosphere interactions
94.30.vb Magnetosphere/ionosphere interactions (see also 94.20.wj—in Physics of the ionosphere)
94.30.vd Magnetosphere interactions with satellites and rings
94.30.vf Solar wind/magnetosphere interactions
94.30.vh Interactions with interplanetary space
94.30.Xy Radiation belts
96. Solar system; planetology
96.10.+i General; solar nebula; cosmogony
96.12.~a Planetology of solid surface planets (see also 96.15.~g Planetology of fluid planets; 96.30.Bc Comparative planetology)
96.12.Bc Origin and evolution
96.12.De Orbital and rotational dynamics
96.12.Fe Gravitational fields
96.12.Hg Magnetic field and magnetism
96.12.J~ Atmospheres
96.12.ka Aurorae and airglow
96.12.jc Composition and chemistry
96.12.je Evolution
96.12.jg Structure and dynamics
96.12.ji Ionospheres
96.12.jk Magnetospheres
96.12.jm Meteorology
96.12.K~ Surfaces
96.12.kd Hydrology and fluvial processes
96.12.kc Surface materials and properties
96.12.ke Impact phenomena, cratering
96.12.kg Erosion, weathering
96.12.ki Glaciation
96.12.Ma Composition
96.12.Pc Interiors
96.12.Qr Polar regions
96.12.St Heat flow
96.12.Uv Rings and dust
96.12.Wx Interactions with particles and fields
96.12.Xy Tectonics, volcanism
96.15.~g Planetology of fluid planets (see also 96.12.~a Planetology of solid surface planets; 96.30.Bc Comparative planetology)
96.15.Bc Origin and evolution
96.15.De Orbital and rotational dynamics
96.15.Ef Gravitational fields
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96.15.hk Ionospheres
96.15.Jn Magnetospheres
96.15.Kc Composition
96.15.Lb Surfaces
96.15.Nd Interiors
96.15.Pf Physical properties of materials
96.15.Qr Impact phenomena
96.15.St Tori and exospheres
96.15.Uv Rings and dust
96.15.Vx Interactions with particles and fields
96.15.Wx Tidal forces
96.15.Xy Polar regions
96.20.~m Moon
96.20.Br Origin and evolution
96.20.Dt Features, landmarks, mineralogy, and petrology
96.20.Jz Gravitational field, selenodyes, and magnetic fields
96.20.Ka Impacts, cratering
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96.25.Pq Impact phenomena
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96.25.St Plasma and MHD instabilities
96.25.Tg Radiation and spectra
96.25.Vt Satellites
96.25.Xz Volcanism
96.30.~t Solar system objects
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96.30.cd Interiors
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96.30.Kf Jupiter
96.30.L~ Jovian satellites
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96.30.Ld Europa
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96.30.N~ Saturnian satellites
96.30.nd Titan
96.30.Pj Uranus
96.30.Qk Uranian satellites
96.30.Rm Neptune
96.30.Sn Pluto
96.30.Td Neptunian satellites
96.30.Up Plutonian satellites
96.30.V~ Dust, extraterrestrial materials
96.30.Vx Interplanetary material
96.30.vv Interstellar material
96.30.Wr Planetary rings
96.30.Xa Kuiper belt, trans-Neptunian objects
96.30.Ys Asteroids, meteoroids
96.30.Za Meteors, meteorites and tektites (see also 91.65.Sn Meteorite mineralogy and petrology; 94.20.Xa Meteor-trail physics; 91.67.gn— in Geophysics Appendix)
96.30.Zp Planetary, asteroid, cometary, and satellite characteristics and properties, see 96.12.~a, 96.15.~g, and 96.25.~f
96.50.~e Interplanetary physics (see also 94.05.~a Space plasma physics)
96.50.Bh Interplanetary magnetic fields
96.50.Ci Solar wind plasma; sources of solar wind
96.50.Dj Interplanetary dust and gas
96.50.Ek Heliosphere and solar wind termination
96.50.Fm Planetary bow shocks; interplanetary shocks
96.50.Hp Oort cloud
96.50.Lp Kuiper belt, see 96.30.Xa
96.50.Mp Meteors, meteoroids, and meteor streams, see 96.30.Za
96.50.Qw Meteoroids, micrometeorites, and tektites, see 96.30.Za
96.50.Pw Particle acceleration
96.50.Qx Corotating streams
96.50.Ry Discontinuities
96.50.S~ Cosmic rays (see also 94.20.wq Solar radiation and cosmic ray effects)
96.50.sb Composition, energy spectra and interactions
96.50.sd Extensive air showers
96.50.sf Interactions with terrestrial matter
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| 96.90.+c Other topics on the Solar system and planetology (restricted to new topics in section 96) |
# NANO SCALE SCIENCE AND TECHNOLOGY SUPPLEMENT

Collection of Applicable Terms from PACS 2008

In the list below, black type indicates terms chosen for the Nanoscale Science and Technology Supplement. Terms in gray type show the placement of the chosen terms within the overall scheme.

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<td><strong>03. Quantum mechanics, field theories, and special relativity</strong></td>
<td>03.67.(\text{--})a Quantum information&lt;br&gt;03.67.Ac Quantum algorithms, protocols, and simulations&lt;br&gt;03.67.Bg Entanglement production and manipulation&lt;br&gt;03.67.Dd Quantum cryptography and communication security&lt;br&gt;03.67.Pp Quantum error correction and other quantum phenomena&lt;br&gt;03.67.Lx Quantum computation architectures and implementations&lt;br&gt;03.67.Hk Quantum communication&lt;br&gt;03.67.Pp Quantum error correction and other methods for protection against decoherence</td>
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<td><strong>04. Electromagnetism, Optics, Acoustics, Heat Transfer, Classical Mechanics, and Fluid Dynamics</strong></td>
<td>47. Fluid dynamics&lt;br&gt;47.61.(\text{--})k Micro- and nano-scale flow phenomena&lt;br&gt;47.61.Cb Non-continuum effects&lt;br&gt;47.61.Fg Flows in micro-electromechanical systems (MEMS) and nano-electromechanical systems (NEMS)&lt;br&gt;47.61.Jd Multiphase flows&lt;br&gt;47.61.Ne Micromixing&lt;br&gt;42. Optics&lt;br&gt;42.50.(\text{--})p Quantum optics&lt;br&gt;42.50.Ex Optical implementations of quantum information processing and transfer&lt;br&gt;42.50.Wk Mechanical effects of light on material media, microstructures and particles&lt;br&gt;42.70.(\text{--})a Optical materials&lt;br&gt;42.70.Qs Photonic bandgap materials&lt;br&gt;42.70.Gc Quantum mechanics, field theories, and special relativity&lt;br&gt;42.70.(\text{--})b Quantum information&lt;br&gt;42.70.Pp Quantum error correction and other quantum phenomena&lt;br&gt;42.70.Lx Quantum computation architectures and implementations&lt;br&gt;42.70.Hk Quantum communication&lt;br&gt;42.70.Pp Quantum error correction and other methods for protection against decoherence</td>
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<td><strong>07. Instruments, apparatus, and components common to several branches of physics and astronomy</strong></td>
<td>07.10.(\text{--})h Mechanical instruments and equipment&lt;br&gt;07.10.Cm Micromechanical devices and systems&lt;br&gt;07.79.(\text{--})v Scanning probe microscopes and components&lt;br&gt;07.79.Cz Scanning tunneling microscopes&lt;br&gt;07.79.Fc Near-field scanning optical microscopes&lt;br&gt;07.79.Lh Atomic force microscopes&lt;br&gt;07.79.Pk Magnetic force microscopes&lt;br&gt;07.79.Sp Friction force microscopes&lt;br&gt;64. Equations of state, phase equilibria, and phase transitions&lt;br&gt;64.70.(\text{--})p Specific phase transitions&lt;br&gt;64.70.Nd Structural transitions in nanoscale materials&lt;br&gt;66. Nonelectronic transport properties of condensed matter&lt;br&gt;66.30.(\text{--})h Diffusion in solids&lt;br&gt;66.30.Pa Diffusion in nanoscale solids&lt;br&gt;68. Surfaces and interfaces; thin films and nanosystems (structure and nonelectronic properties)&lt;br&gt;68.35.(\text{--})p Solid surfaces and solid-solid interfaces; structure and energetics</td>
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<td><strong>05. Condensed matter: structural, mechanical, and thermal properties</strong></td>
<td>60. Condensed matter: structural, mechanical, and thermal properties&lt;br&gt;61. Structure of solids and liquids; crystallography&lt;br&gt;61.46.(\text{--})w Structure of nanoscale materials&lt;br&gt;61.46.Bc Structure of clusters (e.g., metcars; not fragments of crystals; free or loosely aggregated or loosely attached to a substrate)&lt;br&gt;61.46.Df Structure of nanocrystals and nanoparticles (&quot;colloidal&quot; quantum dots but not gate-isolated embedded quantum dots)&lt;br&gt;61.46.Fg Nanotubes&lt;br&gt;61.46.Hk Nanocrystals&lt;br&gt;61.46.Km Structure of nanowires and nanorods (long, free or loosely attached, quantum wires and quantum rods, but not gate-isolated embedded quantum wires)&lt;br&gt;61.46.Np Structure of nanotubes (hollow nanowires)&lt;br&gt;61.48.(\text{--})c Structure of fullerenes and related hollow molecular clusters&lt;br&gt;61.48.De Structure of carbon nanotubes, boron nanotubes, and closely related graphitelike systems&lt;br&gt;62. Mechanical and acoustical properties of condensed matter&lt;br&gt;62.23.(\text{--})c Structural classes of nanoscale systems&lt;br&gt;62.23.Eg Nanodots&lt;br&gt;62.23.Hj Nanowires&lt;br&gt;62.23.Kn Nanosheets&lt;br&gt;62.23.Pq Composites (nanosystems embedded in a larger structure)&lt;br&gt;62.23.St Complex nanostructures, including patterned or assembled structures&lt;br&gt;63. Lattice dynamics&lt;br&gt;63.22.(\text{--})m Phonons or vibrational states in low-dimensional structures and nanoscale materials&lt;br&gt;63.22.Dc Free films&lt;br&gt;63.22.Gh Nanotubes and nanowires&lt;br&gt;63.22.Kn Clusters and nanocrystals&lt;br&gt;63.22.Np Layered systems</td>
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<td>64. Equations of state, phase equilibria, and phase transitions&lt;br&gt;64.70.(\text{--})p Specific phase transitions&lt;br&gt;64.70.Nd Structural transitions in nanoscale materials&lt;br&gt;66. Nonelectronic transport properties of condensed matter&lt;br&gt;66.30.(\text{--})h Diffusion in solids&lt;br&gt;66.30.Pa Diffusion in nanoscale solids&lt;br&gt;68. Surfaces and interfaces; thin films and nanosystems (structure and nonelectronic properties)&lt;br&gt;68.35.(\text{--})p Solid surfaces and solid-solid interfaces; structure and energetics</td>
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68.35.bp Fullerences
68.37.-d Microscopy of surfaces, interfaces, and thin films
68.37.Ef Scanning tunneling microscopy (including chemistry induced with STM)
68.37.Hk Scanning electron microscopy (SEM) (including EBIC)
68.37.Lp Transmission electron microscopy (TEM)
68.37.Ma Scanning transmission electron microscopy (STEM)
68.37.Nq Low energy electron microscopy (LEEM)
68.37.Og High-resolution transmission electron microscopy (HRTEM)
68.37.Ps Atomic force microscopy (AFM)
68.37.Rt Magnetic force microscopy (MFM)
68.37.Tj Acoustic force microscopy
68.37.Uv Near-field scanning microscopy and spectroscopy
68.37.Vj Field emission and field-ion microscopy
68.37.Xy Scanning Auger microscopy, photoelectron microscopy
68.37.Yz X-ray microscopy
68.5.-a Thin film structure and morphology
68.5.-b Nucleation and growth
68.5.-ap Fullerences
68.65.-k Low-dimensional, mesoscopic, and nanoscale systems: structure and nonelectronic properties
68.65.Fg Quantum wells
68.65.Hb Quantum dots (patterned in quantum wells)
68.65.La Quantum wires (patterned in quantum wells)
70. CONDENSED MATTER: ELECTRONIC STRUCTURE, ELECTRICAL, MAGNETIC, AND OPTICAL PROPERTIES
71. Electronic structure of bulk materials
71.20.-b Electron density of states and band structure of crystalline solids
71.20.Tx Fullerences and related materials; intercalation compounds
72. Electronic transport in condensed matter
72.25.-b Spin polarized transport
72.25.Ba Spin polarized transport in metals
72.25.Dc Spin polarized transport in semiconductors
72.25.Fe Optical creation of spin polarized carriers
72.25.Hg Electrical injection of spin polarized carriers
72.25.Mk Spin transport through interfaces
72.25.Pn Current-driven spin pumping
72.25.Rb Spin relaxation and scattering
73.20.-b Conductivity of specific materials
73.20.Rj Fullerences and related materials
73.22.-f Electronic structure of nanoscale materials: clusters, nanoparticles, nanotubes, and nanocrystals
73.22.Dj Single particle states
73.22.Gk Broken symmetry phases
73.22.Lp Collective excitations
73.63.-b Electronic transport in nanoscale materials and structures
73.63.Bd Nanocrystalline materials
73.63.Fg Nanotubes
73.63.Hs Quantum wells
73.63.Kv Quantum dots
73.63.Nm Quantum wires
73.63.Rt Nanoscale contacts
74. Superconductivity
74.70.-b Superconducting materials
74.70.Wz Fullerences and related materials
74.78.-w Superconducting films and low-dimensional structures
74.78.Na Mesoscopic and nanoscale systems
75. Magnetic properties and materials
75.50.-y Studies of specific magnetic materials
75.50.Tt Fine-particle systems; nanocrystalline materials
75.50.Xx Molecular magnets
75.70.-i Magnetic properties of thin films, surfaces, and interfaces
75.75.+a Magnetic properties of nanostructures
78. Optical properties, condensed-matter spectroscopy and other interactions of radiation and particles with condensed matter
78.30.-j Infrared and Raman spectra
78.30.Na Fullerences and related materials
78.40.-q Absorption and reflection spectra: visible and ultraviolet
78.40.Ri Fullerences and related materials
78.66.-w Optical properties of specific thin films
78.66.Tr Fullerences and related materials
78.67.-n Optical properties of low-dimensional, mesoscopic, and nanoscale materials and structures
78.67.Bf Nanocrystals and nanoparticles
78.67.Ch Nanotubes
78.67.De Quantum wells
78.67.Hc Quantum dots
78.67.Lt Quantum wires
79. Electron and ion emission by liquids and solids; impact phenomena
79.60.-i Photoemission and photoelectron spectra
79.60.Jv Interfaces; heterostructures; nanostructures
80. INTERDISCIPLINARY PHYSICS AND RELATED AREAS OF SCIENCE AND TECHNOLOGY
81. Materials science
81.05.-t Specific materials: fabrication, treatment, testing, and analysis
81.05.Tp Fullerences and related materials
81.07.-b Nanoscale materials and structures: fabrication and characterization
81.07.Bc Nanocrystalline materials
81.07.De Nanotubes
81.07.Lk Nanocontacts
81.07.Nb Molecular nanostructures
81.07.Pr Organic-inorganic hybrid nanostructures
81.07.St Quantum wells
81.07.Ta Quantum dots
81.07.Vb Quantum wires
81.07.Wx Nanopowders
81.16.-c Methods of nanofabrication and processing
81.16. Be Chemical synthesis methods
81.16. Dn Self-assembly
81.16. Fg Supramolecular and biochemical assembly
81.16. Hc Catalytic methods
81.16. Mk Laser-assisted deposition
81.16. Nd Nanolithography
81.16. Pr Nanooxidation
81.16. Rf Nanoscale pattern formation
81.16. Ta Atom manipulation

82. Physical chemistry and chemical physics
82.35. Polymers: properties; reactions; polymerization
82.35. Np Nanoparticles in polymers
82.37. Single molecule kinetics
82.37. Gk STM and AFM manipulations of a single molecule
82.37. Rs Single molecule manipulation of proteins and other biological molecules
82.45. Electrochemistry and electrophoresis
82.45. Yz Nanostructured materials in electrochemistry
82.60. Chemical thermodynamics
82.60. Qr Thermodynamics of nanoparticles
82.70. Disperse systems; complex fluids

85. Electronic and magnetic devices; microelectronics
85.35. Nanoelectronic devices
85.35. Be Quantum well devices (quantum dots, quantum wires, etc.)
85.35. Ds Quantum interference devices
85.35. Gv Single electron devices
85.35. Kt Nanotube devices
85.65. Molecular electronic devices
85.75. Magnetoelectronics; spintronics; devices exploiting spin polarized transport or integrated magnetic fields
85.75. Bb Magnetic memory using giant magnetoresistance
85.75. Dd Magnetic memory using magnetic tunnel junctions
85.75. Ff Reprogrammable magnetic logic
85.75. Hh Spin polarized field effect transistors
85.75. Mn Spin polarized resonant tunnel junctions
85.75. Nn Hybrid Hall devices
85.75. Sx Magnetic field sensors using spin polarized transport
85.85. Micro- and nano-electromechanical systems (MEMS/NEMS) and devices

87. Biological and medical physics
87.64. Spectroscopic and microscopic techniques in biophysics and medical physics
87.64. Dz Scanning tunneling and atomic force microscopy
87.64. Ee Electron microscopy
87.80. Biophysical techniques (research methods)
87.80. Ek Mechanical and micromechanical techniques
87.80. Fe Micromanipulation of biological structures
87.80. Nj Single-molecule techniques
87.85. Biomedical engineering
87.85. D Cells on a chip
87.85. J Biomaterials
87.85. Jf Bio-based materials
87.85. Ox Biomedical instrumentation and transducers, including micro-electro-mechanical systems (MEMS)
87.85. Qr Nanotechnologies-design
87.85. Rs Nanotechnologies-applications
87.85. Uv Micromanipulators
87.85. Va Micromachining
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