Appendix A
Basic Notations

In this Appendix, the basic notations for the mathematical operators and astronomical and physical quantities used throughout the book are given. Note that only the most frequently used quantities are mentioned; besides, overlapping symbol definitions and deviations from the basically adopted notations are possible, when appropriate.

Mathematical Quantities and Operators

$\|\mathbf{x}\|$ is the length (norm) of vector **x**
$\mathbf{x} \cdot \mathbf{y}$ is the scalar product of vectors **x** and **y**
$\nabla_{\mathbf{r}}$ is the gradient operator in the direction of vector **r**
$\{f, g\}$ is the Poisson bracket of functions f and g
$K(m)$ or $K(k)$ (where $m = k^2$) is the complete elliptic integral of the first kind with modulus k
$E(m)$ or $E(k)$ is the complete elliptic integral of the second kind
$F(\alpha, m)$ is the incomplete elliptic integral of the first kind
$E(\alpha, m)$ is the incomplete elliptic integral of the second kind
Λ_0 is Heuman's Lambda function
P_i is the Legendre polynomial of degree i
x_0 is the initial value of a variable x

Coordinates and Frames

x, y, z are the Cartesian (orthogonal) coordinates
r, ϕ, α are the spherical coordinates (radial distance, longitude, and latitude)

I. I. Shevchenko, *The Lidov-Kozai Effect – Applications in Exoplanet Research and Dynamical Astronomy*, Astrophysics and Space Science Library 441,
DOI 10.1007/978-3-319-43522-0

In the three-body problem:
$\mathbf{r_1}$ is the position vector of body 1 relative to body 0
$\mathbf{r_2}$ is the position vector of body 2 relative to the center of mass of the inner binary
Φ is the angle between vectors $\mathbf{r}_1$ and $\mathbf{r}_2$
In the many-body problem:
$\mathbf{r}$ and $\mathbf{r}_i$ ($i = 1, \ldots, N$) are the primary-centric positions of a particle and N gravitating perturbers (with masses m_i)
$\mathbf{r}_{i0}$ is the position vector of body i relative to body 0
$\mathbf{r}_{ij}$ the position vector of body i relative to body j

Orbital Elements and Corresponding Quantities

a, e, i, ω, ϖ, Ω, M, l are, respectively the semimajor axis, eccentricity, inclination, argument of pericenter, longitude of pericenter, longitude of ascending node, mean anomaly, mean longitude of a massless test particle or a massive test body
$q = a(1 - e)$ is the pericentric distance
$Q = a(1 + e)$ is the apocentric distance
$a_{\rm pert}$, $e_{\rm pert}$, $i_{\rm pert}$, $\omega_{\rm pert}$, $\varpi_{\rm pert}$, $\Omega_{\rm pert}$, $M_{\rm pert}$, $l_{\rm pert}$ are, respectively the semimajor axis, eccentricity, inclination, argument of pericenter, longitude of pericenter, longitude of ascending node, mean anomaly, mean longitude of a perturber's orbit
$a_{\rm p}$, $e_{\rm p}$ are, respectively the semimajor axis and eccentricity of a planetary orbit
$a_{\rm b}$, $e_{\rm b}$ are, respectively the semimajor axis and eccentricity of a binary
a_1, a_2 are the semimajor axes of the inner and outer binaries, respectively
e_1, e_2 are the eccentricities of the inner and outer binaries, respectively
$\alpha = a_1/a_2$ is the ratio of semimajor axes of the inner and outer binaries
$e_{\rm f}$ is the forced eccentricity
$i_{\rm E}$ is the inclination to the ecliptic plane
e_i, ϖ_i, i_i, and Ω_i are, respectively, the eccentricity, longitude of pericenter, inclination, and longitude of ascending node of planet i
n is the mean motion of a test body
$n_{\rm pert}$ is the mean motion of a perturber
P_1 is the orbital period of the inner binary
P_2 is the orbital period of the outer binary
τ is the time of the pericenter transit

Dynamical Definitions

n is the number of degrees of freedom
$\mathcal{R}$ is the perturbing function
$\mathcal{H}$ is a Hamiltonian
$\mathcal{K}$ is a normalized Hamiltonian

q is the vector of canonical coordinates
p is the vector of conjugate canonical momenta
l, g, h are the Delaunay canonical angles, corresponding to the mean anomaly M, argument of pericenter ω, and longitude of ascending node Ω, respectively
L, G, H are the Delaunay canonical momenta, conjugate to the Delaunay canonical angles
Λ and λ, P and p, Q and q are the pairs of the modified Delaunay variables of the test body
$\omega \equiv \varpi - \Omega$ is the argument of pericenter, the critical angle of the LK-resonance
α is the frequency of the forced (due to a perturbation) precession of ω
T_{LK} is the period of LK-oscillations
ϵ_{oct} is a constant parameter characterizing the role of octupole terms
β_k and δ_k are the planetary angular phases, $k = 1, 2, \ldots, 8$
g_k and s_k are the planetary frequencies, $k = 1, 2, \ldots, 8$
ν_5 is a secular resonance
ν_6 is a secular resonance
ν_{16} is a secular resonance

Masses and Mass Parameters

m_0 is the mass of the "central" body (the primary, usually the most massive in a system)
m is the mass of a test body (e.g., an asteroid, a planet)
m_{pert} is the mass of a perturber
$\mu = m_1/(m_0 + m_1)$ is the mass parameter of a binary
m_{star} is the mass of the parent star in a system
M_{Sun} is the mass of the Sun
m_{pl} is the mass of a planet
ϵ is the mass of the largest planet in a system in units of the mass of the host star

Other Physical Quantities

$\mathcal{G}$ is the gravitational constant
c is the speed of light
R_{p} is the mean radius of a planet
R_{Sun} is the radius of the Sun
R_{Earth} is the radius of the Earth
R_{Moon} is the radius of the Moon
R_{H} is the Hill radius
J_2 is the second zonal harmonic coefficient of a planet
k_2 is the Love number

G is the module of the angular momentum
H is the angular momentum vector's vertical component
ϕ is the angle of the pendulum deviation from the vertical
m is the mass of a pendulum
l is the length of a pendulum
φ is the angle of a pendulum, or a resonance phase angle
p is the momentum of a pendulum
Ω is the perturbation frequency
τ is the phase angle of perturbation
L is the maximum Lyapunov exponent
$T_\mathrm{L} \equiv L^{-1}$ is the Lyapunov time
ω_0 is the frequency of the pendulum small-amplitude oscillations
J is the unitless (scaled) angular momentum of the inner orbit
J_z is the vertical component of the angular momentum
G_1 and G_2 are the angular momenta of the inner and outer binaries, respectively
C_J is the Jacobi integral, also called the Jacobi constant

Appendix B
Astronomical Constants and Parameters

The astronomical constants and parameters given in Table B.1 are merely those that are necessary to make numerical estimates throughout the book. The values of astronomical constants are those adopted by the 16th General Assembly of the International Astronomical Union in 1976.

Table B.1 Astronomical constants and parameters

Constant	Value
Speed of light c	$2.997925 \cdot 10^{10}$ cm/s
Gravitational constant $\mathcal{G}$	$6.672 \cdot 10^{-8}$ g^{-1}cm^{3}s^{-2}
Solar mass M_{Sun}	$1.989 \cdot 10^{33}$ g
Solar radius R_{Sun}	$6.960 \cdot 10^{10}$ cm
Mass of the Earth M_{Earth}	$5.977 \cdot 10^{27}$ g
Equatorial radius of the Earth R_{Earth}	$6.378140 \cdot 10^8$ cm
Mean radius of the Earth $\langle R_{\text{Earth}} \rangle$	$6.371032 \cdot 10^8$ cm
Mean distance "Earth–Moon" a_{EM}	$3.84401 \cdot 10^{10}$ cm
Mass of Jupiter M_{J}	$1.898 \cdot 10^{30}$ g
Semimajor axis of Jupiter's orbit	5.20337 AU
Semimajor axis of Neptune's orbit	30.058 AU
Semimajor axis of Pluto's orbit	39.46 AU
Astronomical unit (AU)	$1.49600 \cdot 10^{13}$ cm
Parsec	$3.0857 \cdot 10^{18}$ cm = 206265 AU
Ecliptic-to-equator obliquity (epoch 2000)	$23°26'21''$
Ratio of masses of the Earth and Moon	81.30
Ratio of masses of the Sun and Earth	332958
Oblateness of the Earth ellipsoid $(a - b)/a$	1/298.257

I. I. Shevchenko, *The Lidov-Kozai Effect – Applications in Exoplanet Research and Dynamical Astronomy*, Astrophysics and Space Science Library 441,
DOI 10.1007/978-3-319-43522-0

References

Abramowitz, M., & Stegun, I. A. (1970) *Handbook of Mathematical Functions* (Dover, New York)

Aksenov, E. P. (1979a) "The doubly averaged, elliptical, restricted, three-body problem." Sov. Astron., **23**, 236–239

Aksenov, E. P. (1979b) "Trajectories in the doubly-averaged elliptical restricted three-body problem." Sov. Astron., **23**, 351–354

Alexander, T. (2005) "Stellar processes near the massive black hole in the Galactic center." Phys. Rep., **419**, 65–142

Antognini, J. M. O. (2015) "Timescales of Kozai–Lidov oscillations at quadrupole and octupole order in the test particle limit." Mon. Not. R. Astron. Soc., **452**, 3610–3619

Antonini, F., Murray, N., & Mikkola, S. (2014) "Black hole triple dynamics: a breakdown of the orbit average approximation and implications for gravitational wave detections." Astrophys. J., **781**, 45 (13pp)

Albrecht, S., Winn, J. N., Johnson, J. A., Howard, A. W., Marcy, G. W., Butler, R. P., *et al.* (2012) "Obliquities of hot jupiter host stars: evidence for tidal interactions and primordial misalignments." Astrophys. J., **757**, 18 (25pp)

Arnold, V. I., Kozlov, V. V., & Neishtadt, A. I. (2002) *Mathematical Aspects of Classical and Celestial Mechanics* (Editorial URSS, Moscow) (in Russian)

Arnold, V. I., Kozlov, V. V., & Neishtadt, A. I. (2006) *Mathematical Aspects of Classical and Celestial Mechanics*, 3rd Edition (Springer, New York)

Bailey, M. E., Chambers, J. E., & Hahn, G. (1992) "Origin of sungrazers: a frequent cometary end-state." Astron. Astrophys., **257**, 315–322

Batygin, K., Laughlin, G., Meschiari, S., Rivera, E., Vogt, S., & Butler, P. (2009) "A quasi-stationary solution to Gliese 436b's eccentricity." Astrophys. J., **699**, 23–30

Batygin, K., Morbidelli, A., & Tsiganis, K. (2011) "Formation and evolution of planetary systems in presence of highly inclined stellar perturbers." Astron. Astrophys., **533**, A7 (8pp)

Belbruno, E. A. (2004) *Capture Dynamics and Chaotic Motions in Celestial Mechanics* (Princeton University Press, Princeton)

Beletsky, V. V. (1972) *Essays on the Motion of Cosmic Bodies* (Nauka Publishers, Moscow) (in Russian)

Begelman, M. C., Blandford, R. D., & Rees, M. J. (1980) "Massive black hole binaries in active galactic nuclei." Nature, **287**, 307–309

I. I. Shevchenko, *The Lidov-Kozai Effect – Applications in Exoplanet Research and Dynamical Astronomy*, Astrophysics and Space Science Library 441,
DOI 10.1007/978-3-319-43522-0

Benest, D. (1988a) “Planetary orbits in the elliptic restricted problem I. The α Centauri system.” Astron. Astrophys., **206**, 143–146

Benest, D. (1988b) “Stable planetary orbits around one component in nearby binary stars.” Celest. Mech., **43**, 47–53

Benest, D. (1989) “Planetary orbits in the elliptic restricted problem II. The Sirius system.” Astron. Astrophys., **223**, 361–364

Beust, H., & Dutrey, A. (2006) “Dynamics of the young multiple system GG Tauri. II. Relation between the stellar system and the circumbinary disk.” Astron. Astrophys., **446**, 137–154

Blaes, O., Lee, M. H., & Socrates, A. (2002) “The Kozai mechanism and the evolution of binary supermassive black holes.” Astrophys. J., **578**, 775–786

Bodenheimer, P., Hubickyj, O., & Lissauer, J. J. (2000) “Models of the in situ formation of detected extrasolar giant planets.” Icarus, **143**, 2–14

Brasser, R. (2001) “Some properties of a two-body system under the influence of the Galactic tidal field.” Mon. Not. R. Astron. Soc., **324**, 1109–1116

Brasser, R., Higuchi, A., & Kaib, N. (2010) “Oort cloud formation at various Galactic distances.” Astron. Astrophys., **516**, A72 (12 pp)

Breiter, S. (2003) “Extended fundamental model of resonance.” Celest. Mech. Dyn. Astron., **85**, 209–218

Broucke, R. A. (2003) “Long-term third-body effects via double averaging.” Journal of Guidance, Control, and Dynamics, **26**, No. 1, 27–32

Brouwer, D., & Clemence, G. M. (1961) *Methods of Celestial Mechanics* (Academic, New York)

Brown, E. W. (1936) “The stellar problem of three bodies. III. The motions of the apse and node with applications to the Moon.” Mon. Not. R. Astron. Soc., **97**, 116–126

Burns, J. A. (1986) “Some background on satellites.” In: *Satellites*, ed. by Burns, J. A., & Matthews, M. S. (Univ. of Arizona Press, Tucson) pp. 1–38

Carruba, V., Burns, J. A., Nicholson, P. D., & Gladman, B. J. (2002) “On the inclination distribution of the Jovian irregular satellites.” Icarus, **158**, 434–449

Carruba, V., Burns, J. A., Nicholson, P. D., & Gladman, B. J. (2003) Erratum to “On the inclination distribution of the Jovian irregular satellites.” Icarus, **162**, 230–231

Chang, Ph. (2009) “The effectiveness of the Kozai mechanism in the Galactic Centre.” Mon. Not. R. Astron. Soc., **393**, 224–228

Chenciner, A., & Montgomery, R. (2000) “A remarkable periodic solution of the three-body problem in the case of equal masses.” Annals of Mathematics – Second Series, **152**, 881–901

Chirikov, B. V. (1959) “Resonance processes in magnetic traps.” Atomnaya Energiya, **6**, 630–638 (in Russian) [Chirikov, B. V. (1960) “Resonance processes in magnetic traps.” J. Nucl. Energy, Part C: Plasma Physics, **1**, 253–260]

Chirikov, B. V. (1979) “A universal instability of many-dimensional oscillator systems.” Phys. Rep., **52**, 263–379

Chirikov, B.V. (1982) “Nonlinear resonances and dynamical stochasticity.” Priroda, No. 7, 15–25 (in Russian)

Claret, A. (1995) “Stellar models for a wide range of initial chemical compositions until helium burning. I. From $X = 0.60$ to $X = 0.80$ for $Z = 0.02$.” Astron. Astrophys. Suppl., **109**, 441–446

Clemence, G. (1947) “The relativity effect in planetary motions.” Rev. Mod. Phys., **19**, 361–364

Cochran, W. D., Hatzes, A., Butler, R. P., & Marcy, G. W. (1997) “The discovery of a planetary companion to 16 Cygni B.” Astrophys. J., **483**, 457–463

Colombo, G., & Franklin, F. A. (1971) “On the formation of the outer satellite groups of Jupiter.” Icarus, **15**, 186–189

Correia, A. C. M., Boué, G., Laskar, J., & Morais, M. H. M. (2013) “Tidal damping of the mutual inclination in hierarchical systems.” Astron. Astrophys., **553**, A39 (15pp)

Danby, J. (1962) *Fundamentals of Celestial Mechanics* (Macmillan, New York)

Davies, M. B., Adams, F. C., Armitage, P., Chambers, J., Ford, E., Morbidelli, A., Raymond, S. N., & Veras, D. (2014) “The long-term dynamical evolution of planetary systems.” In: *Protostars* *and Planets VI*, ed. by Beuther, H., Klessen, R. S., Dullemond, C. P., & Henning, T. (University of Arizona Press, Tucson) pp. 787–808

de la Fuente Marcos, C., & de la Fuente Marcos, R. (2014) "Extreme trans-Neptunian objects and the Kozai mechanism: signalling the presence of trans-Plutonian planets." Mon. Not. R. Astron. Soc., **443**, L59–L63

Demidova, T. V., & Shevchenko, I. I. (2015) "Spiral patterns in planetesimal circumbinary disks." Astrophys. J., **805**, 38 (8pp)

Deprit, A. (1969) "Canonical transformations depending on a small parameter." Celest. Mech., **1**, 12–30

Devaney, R. (1986) *An Introduction to Chaotic Dynamical Systems* (Benjamin/Cummings, Menlo Park)

Doyle, L. R., Carter, J. A., Fabrycky, D. C., *et al.* (2011) "Kepler-16: a transiting circumbinary planet." Science, **333**, 1602–1606

Duncan, M. J., Quinn, T., & Tremaine, S. (1987) "The formation and extent of the solar system comet cloud." Astron. J., **94**, 1330–1338

Dumusque, X., Pepe, F., Lovis, C., *et al.* (2012) "An Earth-mass planet orbiting α Centauri B." Nature, **491**, 207–211

Duquennoy, A., & Mayor, M. (1991) "Multiplicity among solar-type stars in the solar neighbourhood. II — Distribution of the orbital elements in an unbiased sample." Astron. Astrophys., **248**, 485–524

Eggleton, P. P., & Kiseleva-Eggleton, L. (2001) "Orbital evolution in binary and triple stars, with an application to SS Lacertae." Astrophys. J., **562**, 1012–1030

Emelyanov, N. V., & Vashkovyak, M. A. (2012) "Evolution of orbits and encounters of distant planetary satellites. Study tools and examples." Sol. Sys. Res., **46**, 423–435

Fabrycky, D., & Tremaine, S. (2007) "Shrinking binary and planetary orbits by Kozai cycles with tidal friction." Astrophys. J., **669**, 1298–1315

Fang, J., & Margot, J.-L. (2012) "The role of Kozai cycles in near-Earth binary asteroids." Astron. J., **143**, 59 (8pp)

Farago, F., & Laskar, J. (2010) "High-inclination orbits in the secular quadrupolar three-body problem." Mon. Not. R. Astron. Soc., **401**, 1189–1198

Farinella, P., Froeschlé, Ch., & Gonczi, R. (1993) "Meteorites from the asteroid 6 Hebe." Celest. Mech., **56**, 287–305

Farinella, P., Froeschlé, Ch., Froeschlé, C., Gonczi, R., Hahn, G., Morbidelli, A., & Valsecchi, G. B. (1994) "Asteroids falling onto the Sun." Nature, **371**, 314–317

Fernández, J. A. (1997) "The formation of the Oort cloud and the primitive galactic environment." Icarus, **129**, 106–119

Ferraz-Mello, S. (2007) *Canonical Perturbation Theories. Degenerate Systems and Resonance* (Springer, New York)

Ferraz-Mello, S., Michtchenko, T., Beaugé, C., & Callegari, N. Jr. (2005) "Extrasolar planetary systems." In: *Chaos and Stability in Planetary Systems*, ed. by Dvorak, R., Freistetter, F., & Kurths, J. (Lect. Notes Phys., v. 683) (Springer, Heidelberg) pp. 219–271

Ferrer, S., & Osácar, C. (1994) "Harrington's Hamiltonian in the stellar problem of three bodies: reductions, relative equilibria and bifurcations." Celest. Mech. Dyn. Astron., **58**, 245–275

Ford, E. B., Kozinsky, B., & Rasio, F. A. (2000) "Secular evolution of hierarchical triple star systems." Astrophys. J., **535**, 385–401

Fouchard, M., Froeschlé, Ch., Rickman, H., & Valsecchi, G. B. (2011) "The key role of massive stars in Oort cloud comet dynamics." Icarus, **214**, 334–347

Fragner, M. M., Nelson, R. P., & Kley, W. (2011) "On the dynamics and collisional growth of planetesimals in misaligned binary systems." Astron. Astrophys., **528**, A40 (21pp)

Froeschlé, Cl. (1984) "The Lyapunov characteristic exponents — applications to celestial mechanics." Celest. Mech., **34**, 95–115

Froeschlé, Ch., & Morbidelli, A. (1994) "The secular resonances in the solar system." In: *Asteroids, Comets, Meteors 1993*, ed. by Milani, A., di Martino, M., & Cellino, A. (Kluwer, Dordrecht) pp. 189–204

Froeschlé, Ch., Morbidelli, A., & Scholl, H. (1991) "Complex dynamical behaviour of the asteroid 2335 James associated with the secular resonances ν_5 and ν_{16}: numerical studies and theoretical interpretation." Astron. Astrophys., **249**, 553–562

Gallardo, T. (2006) "The occurrence of high-order resonances and Kozai mechanism in the scattered disk." Icarus, **181**, 205–217

Gallardo, T., Hugo, G., & Pais, P. (2012) "Survey of Kozai dynamics beyond Neptune." Icarus, **220**, 392–403

Giacaglia, G. E. O. (1968) "Secular motion of resonant asteroids." Smithsonian Astrophysical Observatory, Special Report No. 278. 70 pp.

Giacaglia, G. E. O. (1969) "Resonance in the restricted problem of three bodies." Astron. J, **74**, 1254–1261

Giacaglia, G. E. O. (1972) *Perturbation Methods in Non-Linear Systems* (Springer, New York)

Gladman, B., Kavelaars, J. J., Holman, M., Nicholson, P. D., Burns, J. A., Hergenrother, C., Petit, J.-M., Marsden, B. G., Jacobson, R., Gray, W., & Grav, T. (2001) "Orbital clustering for twelve newly discovered Saturnian satellites: Evidence for collisional families." Nature, **412**, 163–166

Goldman, B., Marsat, S., Henning, T., Clemens, C., & Greiner, J. (2010) "A new benchmark T8-9 brown dwarf and a couple of new mid-T dwarfs from the UKIDSS DR5+ LAS." Mon. Not. R. Astron. Soc., **405**, 1140–1152

Goldreich, P. (1966) "History of the Lunar orbit." Review of Geophysics and Space Physics, **4**, 411–439

Goldreich, P., Murray, N., Longaretti, P. Y., & Banfield, D. (1989) "Neptune's story." Science, **245**, 500–504

Gopakumar, A., Bagchi, M., & Ray, A. (2009) "Ruling out Kozai resonance in highly eccentric galactic binary millisecond pulsar PSR J1903+0327." Mon. Not. R. Astron. Soc., **399**, L123–L127

Gordeeva, Yu. F. (1968) "The time dependence of elements in the long-period oscillations in the restricted three-body problem." Cosmic Research, **6**, 450–453

Gould, A., & Quillen, A. C. (2003) "Sagittarius A* companion S0-2: a probe of very high mass star formation." Astrophys. J., **592**, 935–940

Greenberg, R., & Van Laerhoven, C. (2012) "Aligned major axes in a planetary system without tidal evolution: The 61 Virginis example." Mon. Not. R. Astron. Soc., **419**, 429–435

Gronchi, G. F., & Milani, A. (1998) "Averaging on Earth-crossing orbits." Celest. Mech., **71**, 109–136

Gronchi, G. F., & Milani, A. (1999) "The stable Kozai state for asteroids and comets, with arbitrary semimajor axis and inclination." Astron. Astrophys., **341**, 928–935

Haghighipour, N., Dvorak, R., & Pilat-Lohinger, E. (2010) "Planetary dynamics and habitable planet formation in binary star systems." In: *Planets in Binary Star Systems*, ed. by Haghighipour, N. (Springer, Dordrecht) pp. 285–327

Hagihara, Y. (1972) *Celestial Mechanics* Vol. 2, Part 2 (MIT Press, Cambridge)

Hamilton, D. P., & Burns, J. A. (1992) "Orbital stability zones about asteroids. II. The destabilizing effects of eccentric orbits and of solar radiation." Icarus, **96**, 43–64

Harrington, R. S. (1968) "Dynamical evolution of triple stars." Astron. J., **73**, 190–194

Harrington, R. S. (1969) "The stellar three-body problem." Celest. Mech., **1**, 200–209

Hauser, H. M., & Marcy, G. W. (1999) "The orbit of 16 Cygni AB." Publ. Astron. Soc. Pacific, **111**, 321–334

Hayes, W. B. (2007) "Is the outer Solar System chaotic?" Nature Phys., **3**, 689–691

Hayes, W. B. (2008) "Surfing on the edge: chaos versus near-integrability in the system of Jovian planets." Mon. Not. R. Astron. Soc., **386**, 295–306

Hayes, W. B., Malykh, A. V., & Danforth, C. M. (2010) "The interplay of chaos between the terrestrial and giant planets." Mon. Not. R. Astron. Soc., **407**, 1859–1865

Heisler, J., & Tremaine, S. (1986) "The influence of the galactic tidal field on the Oort comet cloud." Icarus, **65**, 13–26

Henrard, J., & Lemaître, A. (1983) "A second fundamental model for resonance." Celest. Mech., **30**, 197–218

Heppenheimer, T. A., & Porco, C. C. (1977) "New contributions to the problem of capture." Icarus, **30**, 385–401

Heppenheimer, T. A. (1978) "On the formation of planets in binary star systems." Astron. Astrophys., **65**, 421–426

Higuchi, A., Kokubo, E., Kinoshita, H., & Mukai, T. (2007) "Orbital evolution of planetesimals due to the Galactic tide: formation of the comet cloud." Astron. J., **134**, 1693–1706

Holman, M. J., & Murray, N. W. (1996) "Chaos in high-order mean motion resonances in the outer asteroid belt." Astron. J., **112**, 1278–1293

Holman, M., Touma, J., & Tremaine, S. (1997) "Chaotic variations in the eccentricity of the planet orbiting 16 Cygni B." Nature, **386**, 254–256

Hori, G. I. (1966) "General perturbations theory with unspecified canonical variables." Publ. Astron. Soc. Japan, **18**, 287–296

Huang, S.-S. (1960) "Life-supporting regions in the vicinity of binary systems." Publ. Astron. Soc. Pacific, **72**, 106–114

Iben, I., Jr., & Tutukov, A. V. (1984) "Supernovae of type I as end products of the evolution of binaries with components of moderate initial mass ($M \lesssim 9M_{\odot}$)." Astrophys. J. Suppl., **54**, 335–372

Innanen, K. A., Zheng, J. Q., Mikkola, S., & Valtonen, M. J. (1997) "The Kozai mechanism and the stability of planetary orbits in binary star systems." Astron. J., **113**, 1915–1919

Ivanov, P. B., & Papaloizou, J. C. B. (2004) "On the tidal interaction of massive extra solar planets on highly eccentric orbits." Mon. Not. R. Astron. Soc., **347**, 437–453

Ivanov, P. B., & Papaloizou, J. C. B. (2011) "Close encounters of a rotating star with planets in parabolic orbits of varying inclination and the formation of hot Jupiters." Celest. Mech. Dyn. Astron., **111**, 51–82

Jefferys, W. H., & Moser, J. (1966) "Quasi-periodic solutions for the three-body problem." Astron. J., **71**, 568–578

Kaib, N. A., Raymond, S. N., & Duncan, M. (2013) "Planetary system disruption by Galactic perturbations to wide binary stars." Nature, **493**, 381–384

Kalas, P., Graham, J. R., & Clampin, M. (2005) "A planetary system as the origin of structure in Fomalhaut's dust belt." Nature, **435**, 1067–1070

Katz, B., Dong, S., & Malhotra, R. (2011) "Long-term cycling of Kozai–Lidov cycles: Extreme eccentricities and inclinations excited by a distant eccentric perturber." Phys. Rev. Lett., **107**, 181101 (5pp)

Kholshevnikov, K. V. (1985) *Asymptotic methods of celestial mechanics* (Leningrad State Univ., Leningrad) (in Russian)

Kholshevnikov, K. V. (1997) "D'Alembertian functions in celestial mechanics." Astron. Rep., **41**, 135–142

Kholshevnikov, K. V. (2001) "The Hamiltonian in the planetary or satellite problem as a D'Alembertian function." Astron. Rep., **41**, 135–142, **45**, 577–579

Kinoshita, H., & Nakai, H. (1999) "Analytical solution of the Kozai resonance and its application." Celest. Mech. Dyn. Astron., **75**, 125–147

Kinoshita, H., & Nakai, H. (2007) "General solution of the Kozai mechanism." Celest. Mech. Dyn. Astron., **98**, 67–74

Kirkwood, D. (1867) *Meteoric Astronomy* (Lippincott, Philadelphia)

Kiseleva, L. G., Eggleton, P. P., & Mikkola, S. (1998) "Tidal friction in triple stars." Mon. Not. R. Astron. Soc., **300**, 292–392

Knežević, Z., & Milani, A. (1994) "Asteroid proper elements: the big picture." In: *Asteroids, Comets, Meteors 1993*, ed. by Milani, A., di Martino, M., & Cellino, A. (Kluwer, Dordrecht) pp. 143–158

Kolomensky, A. A., & Lebedev, A. N. (1966) *Theory of Cyclic Accelerators* (Wiley, New York)

Kozai, Y. (1962) "Secular perturbations of asteroids with high inclination and eccentricity." Astron. J., **67**, 591–598

Kozai, Y. (1979) "Secular perturbations of asteroids and comets." In: *Dynamics of the Solar System*, ed. by Duncombe, R. L. (Reidel, Dordrecht) pp. 231–237

Kozai, Y. (1980) “Asteroids with large secular orbital variations.” Icarus, **41**, 89–95
Kozai, Y. (1985) “Secular perturbations of resonant asteroids.” Celest. Mech., **36**, 47–69
Kozai, Y. (2012) “Kozai mechanism.” In: *Asteroids, Comets, Meteors 2012*, Proceedings of the conference held May 16–20, 2012 in Niigata, Japan. LPI Contribution No. 1667, id. 6195
Krasinsky, G. A. (1972) “Critical inclinations in planetary problems.” Celest. Mech., **6**, 60–83
Krasinsky, G. A. (1974) “Stationary solutions of the averaged three-body problem and some problems of planet motion stability.” In: *The Stability of the Solar System and of Small Stellar Systems* (IAU Symp. No. 62), ed. by Kozai, Y. (Springer, Berlin) pp. 95–116
Kreutz, H. C. F. (1888) “Untersuchungen uber das cometensystem 1843 I, 1880 I und 1882 II.” (Druck von C. Schaidt, Kiel)
Krymolowski, Y., & Mazeh, T. (1999) “Studies of multiple stellar systems – II. Second-order averaged Hamiltonian to follow long-term orbital modulations of hierarchical triple systems.” Mon. Not. R. Astron. Soc., **304**, 720–732
Kushnir, D., Katz, B., Dong, S., Livne, E., & Fernández, R. (2013) “Head-on collisions of white dwarfs in triple systems could explain Type Ia supernova.” Astrophys. J., **778**, L37 (6pp)
Kuzuhara, M., Tamura, M., Ishii, M., Kudo, T., Nishiyama, S., & Kandori, R. (2011) “The widest-separation substellar companion candidate to a binary T Tauri star.” Astron. J., **141**, 119 (10pp)
Laplace, P. S. (1805) *Mécanique Céleste*, V. 4 (Courcier, Paris)
Laskar, J. (1989) “A numerical experiment on the chaotic behaviour of the Solar system.” Nature, **338**, 237–238
Laskar, J. (1990) “The chaotic motion of the solar system: a numerical estimate of the size of the chaotic zones.” Icarus, **88**, 266–291
Laskar, J. (1994) “Large-scale chaos in the solar system.” Astron. Astrophys., **287**, L9–L12
Lawler, S. M., & Gladman, B. (2013) “Plutino detection biases, including the Kozai resonance.” Astronomical Journal, **146**, 6 (13pp)
Lee, M. H., & Peale, S. (2003) “Secular evolution of hierarchical planetary systems.” Astrophys. J., **592**, 1201–1216 [Erratum: (2003) Astrophys. J., **597**, 644 (1p)]
Leigh, N., Knigge, Ch., Sills, A., Perets, H. B., Sarejedini, A., & Glebbeek, E. (2013) “The origins of blue stragglers and binarity in globular clusters.” Mon. Not. R. Astron. Soc., **428**, 897–905
Lemaître, A. (1984) “High-order resonances in the restricted three-body problem.” Celest. Mech. Dyn. Astron., **32**, 109–126
Li, G., Naoz, S., Kocsis, B., & Loeb, A. (2014a) “Eccentricity growth and orbit flip in near-coplanar hierarchical three-body systems.” Astrophys. J., **785**, 116 (8pp)
Li, G., Naoz, S., Holman, M., & Loeb, A. (2014b) “Chaos in the test particle eccentric Kozai–Lidov mechanism.” Astrophys. J., **791**, 86 (10pp) [Erratum: (2015) Astrophys. J., **802**, 71 (1p)]
Li, G., Naoz, S., Kocsis, B., & Loeb, A. (2015) “Implications of the eccentric Kozai–Lidov mechanism for stars surrounding supermassive black hole binaries.” Mon. Not. R. Astron. Soc., **451**, 1341–1349
Libert, A.-S., & Henrard, J. (2007) “Exoplanetary systems: The role of an equilibrium at high mutual inclination in shaping the global behavior of the 3-D secular planetary three-body problem.” Icarus, **191**, 469–485
Lichtenberg, A. J., & Lieberman, M. A. (1992) *Regular and Chaotic Dynamics.* 2nd edition (Springer-Verlag, New York)
Lidov, M. L. (1961) “Evolution of artificial planetary satellites under the action of gravitational perturbations due to external bodies.” Iskusstviennye Sputniki Zemli (Artificial Satellites of the Earth), **8**, 5–45 (in Russian)
Lidov, M. L. (1962) “The evolution of orbits of artificial satellites of planets under the action of gravitational perturbations of external bodies.” Planet. Space Sci., **9**, 719–759 (An English translation of Lidov’s (1961) article.)
Lidov, M. L. (1963a) “Evolution of the orbits of artificial satellites of planets as affected by gravitational perturbation from external bodies.” AIAA Journal, **1**, 1985–2002 (An English translation of Lidov’s (1961) article.)
Lidov, M. L. (1963b) “On the approximate analysis of the evolution of orbits of artificial satellites.” In: *Problems of the Motion of Artificial Celestial Bodies.* (Reports at the Conference on general

and applied problems of theoretical astronomy. Moscow, November 20–25, 1961.) (Publishers of the USSR Academy of Sciences, Moscow) pp. 119–134 (in Russian) [Available at NASA ADS: 1963pmac.book..119L, including incomplete English translation.]

Lidov, M. L. (1963c) "On the approximated analysis of the orbit evolution of artificial satellites." In: *Dynamics of Satellites* (IUTAM Symp.), ed. by Roy, M. (Springer, Berlin) pp. 168–179

Lidov, M. L. (2010) *A Course of Lectures on Theoretical Mechanics* 2nd edition (FIZMATLIT, Moscow) (in Russian)

Lidov, M. L., & Ziglin, S. L. (1974) "The analysis of the restricted circular twice-averaged three body problem in the case of close orbit." Celest. Mech., **9**, 151–173

Lidov, M. L., & Ziglin, S. L. (1976) "Non-restricted double-averaged three body problem in Hill's case." Celest. Mech., **13**, 471–481

Lithwick, Y., & Naoz, S. (2011) "The eccentric Kozai mechanism for a test particle." Astrophys. J., **742**, 94 (8pp)

Löckmann, U., Baumgardt, H., & Kroupa, P. (2008) "Origin of the S stars in the Galactic center." Astrophys. J., **683**, L151–L154

Lovis, C., Ségransan, D., Mayor, M., Udry, S., Benz, W., Bertaux, J.-L., Bouchy, F., Correia, A. C. M., Laskar, J., Lo Curto, G., Mordasini, C., Pepe, F., Queloz, D., & Santos, N. C. (2011) "The HARPS search for southern extra-solar planets. XXVIII. Up to seven planets orbiting HD 10180: probing the architecture of low-mass planetary systems." Astron. Astrophys., **528**, A112 (16pp)

Lu, J. R., Ghez, A. M., Hornstein, S. D., Morris, M., Matthews, K., Thompson D. J., & Becklin E. E. (2006) "Galactic center youth: orbits and origins of the young stars in the central parsec." Journal of Physics Conference Series, **54**, 279–287

Luhman, K. L., Burgasser, A. J., Labbé, I., Saumon, D., Marley, M. S., Bochanski, J. J., Monson, A. J., & Persson, S. E. (2012) "Confirmation of one of the coldest known brown dwarfs." Astrophys. J., **744**, 135 (8pp)

Malhotra, R. (1998) "Orbital resonances and chaos in the Solar system." In: *Solar System Formation and Evolution* (ASP Conf. Ser. 149), ed. by Lazzaro, D., Vieira Martins, R., Ferraz-Mello, S., Fernández, J., & Beaugé, C. (Astron. Soc. of the Pacific, San Francisco) pp. 37–63

Malhotra, R., & Williams, J. G. (1997) "Pluto's heliocentric orbit." In: *Pluto and Charon*, ed. by Stern, S. A., & Tholen, D. (Univ. of Arizona Press, Tucson) pp. 127–157

Malhotra, R. (2012) "Orbital resonances in planetary systems." In: *Encyclopedia of Life Support Systems by UNESCO.* Volume 6.119.55 *Celestial Mechanics*. 31 pp.

Malmberg, D., Davies, M. B., & Chambers, J. E. (2007) "The instability of planetary systems in binaries: how the Kozai mechanism leads to strong planet-planet interactions." Mon. Not. R. Astron. Soc., **377**, L1–L4

Marchal, C. (1990) *The Three-Body Problem* (Elsevier, Amsterdam)

Mardling, R. A., & Aarseth, S. J. (2001) "Tidal interactions in star cluster simulations." Mon. Not. R. Astron. Soc., **321**, 398–420

Markeev, A. P. (1990) *Theoretical Mechanics* (Nauka Publishers, Moscow) (in Russian)

Marzari, F., & Barbieri, M. (2007) "Planet dispersal in binary systems during transient multiple star phases." Astron. Astrophys., **472**, 643–647

Matese, J. J., & Lissauer, J. J. (2002) "Characteristics and frequency of weak stellar impulses of the Oort cloud." Icarus, **157**, 228–240

Matese, J. J., & Whitman, P. G. (1989) "The galactic disk tidal field and the nonrandom distribution of observed Oort cloud comets." Icarus, **82**, 389–401

Matese, J. J., & Whitman, P. G. (1992) "A model of the Galactic tidal interaction with the Oort comet cloud." Celest. Mech. Dyn. Astron., **54**, 13–35

Mathieu, R. D., Ghez, A. M., Jensen, E. L. N., & Simon, M. (2000) "Young binary stars and associated disks." In: *Protostars and Planets IV* (Univ. Arizona Press, Tucson) pp. 703–730

Mayor, M., & Queloz, D. (1995) "A Jupiter-mass companion to a solar-type star." Nature, **378**, 355–359

Mazeh, T., & Shaham, J. (1979) "The orbital evolution of close triple systems — the binary eccentricity." Astron. Astrophys., **77**, 145–151

Mazeh, T., Goldberg, D., Duquennoy, A., & Mayor, M. (1992) "On the mass-ratio distribution of spectroscopic binaries with solar-type primaries." Astrophys. J., **401**, 265–268

Mazeh, T., Krymolowski, Y., & Rosenfeld, G. (1997) "The high eccentricity of the planet orbiting 16 Cygni B." Astrophys. J., **477**, L103–L106

McCrea, W. H. (1964) "Extended main-sequence of some stellar clusters." Mon. Not. R. Astron. Soc., **128**, 147–155

McMillan, S., Hut, P., & Makino, J. (1991) "Star cluster evolution with primordial binaries. II – Detailed analysis." Astrophys. J., **372**, 111–124

Meiss, J.D. (1992) "Symplectic maps, variational principles, and transport." Rev. Mod. Phys., **64**, 795–848

Melnikov, A. V. (2016) "On the chaotic orbital dynamics of the planet in the system 16 Cyg." Astron. Lett., **42**, 115–125

Meschiari, S. (2012a) "Circumbinary planet formation in the Kepler-16 system. I. N-body simulations." Astrophys. J., **752**, 71 (6pp)

Meschiari, S. (2012b) "Planet formation in circumbinary configurations: Turbulence inhibits planetesimal accretion." Astrophys. J., **761**, L7 (5pp)

Meschiari, S. (2014) "Circumbinary planet formation in the Kepler-16 system. II. A toy model for in-situ planet formation within a debris belt." Astrophys. J., **790**, 41 (14pp)

Michaely, E., Perets, H. B., & Grishin, E. (2015) "On the existence of regular and irregular outer moons orbiting the Pluto–Charon system." ArXiv: 1506.08818 [astro-ph.EP] (20pp)

Michel, P., & Thomas, F. (1996) "The Kozai resonance for near-Earth asteroids with semimajor axes smaller than 2 AU." Astron. Astrophys., **307**, 310–318

Milani, A., & Knežević, Z. (1990) "Secular perturbation theory and computation of asteroid proper elements." Celest. Mech., **49**, 347–411

Miller, M. C., & Hamilton, D. P. (2002a) "Four-body effects in globular cluster black hole coalescence." Astrophys. J., **576**, 894–898

Miller, M. C., & Hamilton, D. P. (2002b) "Production of intermediate-mass black holes in globular clusters." Mon. Not. R. Astron. Soc., **330**, 232–240

Moiseev, N. D. (1945a) "On some basic simplified schemes of celestial mechanics obtained by means of averaging the restricted circular three-body problem. Part 1." Publications of the Sternberg State Astronomical Institute (Moscow State Univ.), **15**, issue 1, pp. 75–99 (in Russian, the issue was typeset in 1941)

Moiseev, N. D. (1945b) "On some basic simplified schemes of celestial mechanics obtained by means of averaging the restricted circular three-body problem. Part 2." Publications of the Sternberg State Astronomical Institute (Moscow State Univ.), **15**, issue 1, pp. 100–117 (in Russian, the issue was typeset in 1941)

Moons, M., & Morbidelli, A. (1995) "Secular resonances inside mean-motion commensurabilities: the 4/1, 3/1, 5/2 and 7/3 cases." Icarus, **114**, 33–50

Moons, M., Morbidelli, A., & Migliorini, F. (1998) "Dynamical structure of the 2/1 commensurability and the origin of the resonant asteroids." Icarus, **135**, 458–468

Morbidelli, A. (1993) "Asteroid secular resonant proper elements." Icarus, **105**, 48–66

Morbidelli, A. (2002) *Modern Celestial Mechanics* (Taylor and Francis, London)

Morbidelli, A., & Henrard J. (1991a) "Secular resonances in the asteroid belt: theoretical perturbation approach and the problem of their location." Celest. Mech., **51**, 131–167

Morbidelli, A., & Henrard J. (1991b) "The main secular resonances ν_6, ν_5 and ν_{16} in the asteroid belt." Celest. Mech., **51**, 169–197

Moriwaki, K., & Nakagawa, Y. (2004) "A planetesimal accretion zone in a circumbinary disk." Astrophys. J., **609**, 1065–1070

Murray, C. D., & Dermott, S. F. (1999) *Solar System Dynamics* (Cambridge Univ. Press, Cambridge)

Murray, N. W., & Holman, M. J. (1997) "Diffusive chaos in the outer asteroid belt." Astron. J., **114**, 1246–1259

Murray, N., & Holman, M. (1999) "The origin of chaos in the outer Solar system." Science, **283**, 1877–1881

Nagasawa, M., Ida, S., & Bessho, T. (2008) "Formation of hot planets by a combination of planet scattering, tidal circularization, and the Kozai mechanism." Astrophys. J., **678**, 498–508

Nakai, H., & Kinoshita, H. (1985) "Secular perturbations of asteroids in secular resonances." Celest. Mech., **36**, 391–407

Naoz, S., Farr, W. M., & Rasio, F. A. (2012) "On the formation of hot Jupiters in stellar binaries." Astrophys. J., **754**, L36 (6pp)

Naoz, S., Perets, H. B., & Ragozzine, D. (2010) "The observed orbital properties of binary minor planets." Astrophys. J., **719**, 1775–1783

Naoz, S., Farr, W. M., Lithwick, Y., Rasio, F. A., & Teyssandier, J. (2011) "Hot Jupiters from secular planet-planet interactions." Nature, **473**, 187–189

Naoz, S., Farr, W. M., Lithwick, Y., Rasio, F. A., & Teyssandier, J. (2013a) "Secular dynamics in hierarchical three-body systems." Mon. Not. R. Astron. Soc., **431**, 2155–2171

Naoz, S., Kocsis, B., Loeb, A., & Yunes, N. (2013b) "Resonant post-newtonian eccentricity excitation in hierarchical three-body systems." Astrophys. J., **773**, 187 (16pp)

Naoz, S., & Silk, J. (2014) "Formation of dark matter tori around supermassive black holes via the eccentric Kozai–Lidov mechanism." Astrophys. J., **795**, 102 (11pp)

Nesvorný, D., Roig, F., & Ferraz-Mello, S. (2000) "Close approaches of trans-Neptunian objects to Pluto have left observable signatures on their orbital distribution." Astron. J., **119**, 953–969

Nesvorný, D., Alvarellos, J. L. A., Dones, L., & Levison, H. F. (2003) "Orbital and collisional evolution of the irregular satellites." Astron. J., **126**, 398–429

Oort, J. H. (1950) "The structure of the cloud of comets surrounding the Solar System and a hypothesis concerning its origin." Bull. Astron. Inst. Neth., **11**, 91–110

Orosz, J. A., Welsh, W. F., Carter, J. A., Fabrycky, D. C., Cochran, W. D., *et al.* (2012) "Kepler-47: a transiting circumbinary multiplanet system." Science, **337**, 1511–1514

Paardekooper, S.-J., Leinhardt, Z. M., Thébault, T., & Baruteau, C. (2012) "How not to build Tatooine: the difficulty of in situ formation of circumbinary planets Kepler 16b, Kepler 34b, and Kepler 35b." Astrophys. J., **754**, L16 (5pp)

Paumard, T., Genzel, R., Martins, F., Nayakshin, S., Beloborodov, A. M., Levin, Y., Trippe, S., Eisenhauer, F., Ott, T., Gillessen, S., Abuter, R., Cuadra, J., Alexander, T., & Sternberg, A. (2006) "The two young star disks in the central parsec of the Galaxy: properties, dynamics, and formation." Astrophys. J., **643**, 1011–1035

Perets, H. B., & Fabrycky, D. C. (2009) "On the triple origin of blue stragglers." Astrophys. J., **697**, 1048–1056

Perets, H. B., & Naoz, S. (2009) "Kozai cycles, tidal friction, and the dynamical evolution of binary minor planets." Astrophys. J., **699**, L17–L21

Pinsonneault, M. H., & Stanek, K. Z. (2006) "Binaries like to be twins: implications for doubly degenerate binaries, the type Ia Supernova rate, and other interacting binaries." Astrophys. J., **639**, L67–L70

Poincaré, H. (1899) *Les Méthodes Nouvelles de la Mécanique Céleste III* (Gauthier–Villars, Paris)

Poincaré, H. (1905) *Leçons de Mécanique Céleste* (Gauthier–Villars, Paris)

Pollack, J. B., Burns, J. A., & Tauber, M. E. (1979) "Gas drag in primordial circumplanetary envelopes: A mechanism for satellite capture." Icarus, **37**, 587–611

Pollack, J. B., Lunine, J. I., & Tittemore, W. C. (1991) "Origin of the Uranian satellites." In: *Uranus*, ed. by Bergstrahl, J. T., Miner, E. D., & Matthews, M. S. (Univ. Arizona Press, Tucson) pp. 469–512

Prodan, S., Murray, N., & Thompson, T. A. (2013) "On WD–WD mergers in triple systems: the role of Kozai resonance with tidal friction." ArXiv: 1305.2191 [astro-ph.SR] (8pp)

Prokhorenko, V. I. (2002a) "Investigation of periods of evolution for elliptical orbits in the double-averaged Hill problem." Cosmic Research, **40**, 48–54

Prokhorenko, V. I. (2002b) "Investigation of the time of ballistic existence for elliptic orbits evolving under the influence of gravitational perturbations of external bodies" Cosmic Research, **40**, 264–273

Prokhorenko, V. I. (2015) "On the application of qualitative methods of perturbation theory in solving practical problems of selection and correction of the orbits of the satellites of the planets

given the secular and long-period components of the evolution under the influence of external gravitational perturbations." In: *Space Ballistics — from its Origin to the Future.* (Institute of Space Research, Russian Academy of Sciences, Moscow) pp. 130–161 (in Russian)
Quinn, T., Tremaine, S., & Duncan, M. (1990) "Planetary perturbations and the origin of short-period comets." Astrophys. J., **355**, 667–679
Raghavan, D., McAlister, H. A., Henry, T. J., *et al.* (2010) "A survey of stellar families: multiplicity of Solar-type stars." Astrophys. J. Suppl., **190**, 1–42
Ragozzine, D., & Wolf, A. S. (2009) "Probing the interiors of very hot Jupiters using transit light curves." Astrophys. J., **698**, 1778–1794
Raushenbakh, B. V., & Ovchinnikov, M. Yu. (1997) *Lectures on Dynamics of Spaceflight* (Moscow Physics–Technical Institute, Moscow) (in Russian)
Riddle, R. L., Tokovinin, A., Mason, B. D., *et al.* (2015) "A survey of the high order multiplicity of nearby Solar-type binary stars with Robo–AO." Astrophys. J., **799**, 4 (21pp)
Rein, H. (2012) "Period ratios in multiplanetary systems discovered by Kepler are consistent with planet migration." Mon. Not. R. Astron. Soc., **427**, L21–L24
Roy, A. E. (1988) *Orbital Motion* (Adam Hilger, Bristol)
Saha, P., & Tremaine, S. (1993) "The orbits of the retrograde jovian satellites." Icarus, **106**, 549–562
Sahu, K. C., Casertano, S., Bond, H. E., *et al.* (2006) "Transiting extrasolar planetary candidates in the Galactic bulge." Nature, **443**, 534–540
Sandage, A. R. (1953) "The color-magnitude diagram for the globular cluster M 3." Astron. J., **58**, 61–75
Seto, N. (2013) "Highly eccentric Kozai mechanism and gravitational-wave observation for neutron-star binaries." Phys. Rev. Lett., **111**, 061106 (5pp)
Shappee, B. J., & Thompson, T. A. (2013) "The mass-loss-induced eccentric Kozai mechanism: a new channel for the production of close compact object–stellar binaries." Astrophys. J., **766**, 64 (12pp)
Shevchenko, I. I. (2000) "Geometry of a chaotic layer." J. Exp. Theor. Phys., **91**, 615–625
Shevchenko, I. I. (2002) "On the maximum Lyapunov exponents of the chaotic rotation of natural planetary satellites." Cosmic Research, **40**, 296
Shevchenko, I. I. (2007) "On the Lyapunov exponents of the asteroidal motion subject to resonances and encounters." In: *Near Earth Objects, our Celestial Neighbors: Opportunity and Risk* (Proc. IAU Symp. 236), ed. by Milani, A., Valsecchi, G. B., & Vokrouhlický, D. (Cambridge Univ. Press, Cambridge) pp. 15–29
Shevchenko, I. I. (2011a) "Lyapunov and diffusion timescales in the solar neighborhood." Astrophys. J., **733**, 39 (8pp)
Shevchenko, I. I. (2011b) "The Kepler map in the three-body problem." New Astronomy, **16**, 94–99
Shevchenko, I. I. (2014) "Lyapunov exponents in resonance multiplets." Phys. Lett. A, **378**, 34–42
Shevchenko, I. I. (2015) "Chaotic zones around gravitating binaries." Astrophys. J., **799**, 8 (7pp)
Shinkin, V. N. (1995) "The integrable cases of the general spatial three-body problem at third-order resonance." Celest. Mech. Dyn. Astron., **62**, 323–334
Söderhjelm, S. (1984) "Third-order and tidal effects in the stellar three-body problem." Astron. Astrophys., **141**, 232–240
Soter, S. (2006) "What is a planet?" Astron. J., **132**, 2513–2519
Stern, S. A., & Levison, H. F. (2002) "Regarding the criteria for planethood and proposed planetary classification schemes." Highlights of Astronomy, **12**, 205–213
Sterne, T. E. (1939) "Apsidal motion in binary stars." Mon. Not. R. Astron. Soc., **99**, 451–462
Steffen, J. H., *et al.* (2012) "Kepler constraints on planets near hot Jupiters." Proceedings of the National Academy of Science, **109**, 7982–7987
Stevenson, D. J., Harris, A. W., & Lunine, J. I. (1986) "Origins of satellites." In: *Satellites*, ed. by Burns, J. A., & Matthews, M. S. (Univ. Arizona Press, Tucson) 39–88
Subbotin, M. F. (1968) *An Introduction to Theoretical Astronomy* (Nauka Publishers, Moscow) (in Russian)

Šubr, L., & Karas, V. (2005) "On highly eccentric stellar trajectories interacting with a self-gravitating disc in Sgr A*." Astron. Astrophys., **433**, 405–413
Šubr, L., Karas, V., & Huré, J.-M. (2004) "Star-disc interactions in a galactic centre and oblateness of the inner stellar cluster." Mon. Not. R. Astron. Soc., **354**, 1177–1188
Sussman, G.J., & Wisdom, J. (1988) "Numerical evidence that Pluto is chaotic." Science, **241**, 433–437
Sussman, G. J., & Wisdom, J. (1992) "Chaotic evolution of the solar system." Science, **257**, 56–62
Šuvakov, M., & Dmitrašinović, V. (2013) "Three classes of Newtonian three-body planar periodic orbits." Phys. Rev. Lett., **110**, 114301 (4pp)
Szebehely, V. (1967) *The Theory of Orbits* (Academic Press, New York)
Takeda, G., & Rasio, F. A. (2005) "High orbital eccentricities of extrasolar planets induced by the Kozai mechanism." Astrophys. J., **627**, 1001–1010
Tamayo, D., Burns, J. A., Hamilton, D. P., & Nicholson, P. D. (2013) "Dynamical instabilities in high-obliquity systems." Astron. J., **145**, 54 (12pp)
Thébault, P., Marzari, F., Scholl, H. (2006) "Relative velocities among accreting planetesimals in binary systems: The circumprimary case." Icarus, **183**, 193–206
Thomas, F. (1998) "La dynamique résonnante dans le système solaire. Application au mouvement des objets transneptuniens." Ph. D. thesis (Obs. de Paris, Paris)
Thomas, F., & Morbidelli, A. (1996) "The Kozai resonance in the outer solar system and the dynamics of long-period comets." Celest. Mech. Dyn. Astron., **64**, 209–229
Thompson, T. A. (2011) "Accelerating compact object mergers in triple systems with the Kozai resonance: a mechanism for "prompt" type Ia supernovae, gamma-ray bursts, and other exotica." Astrophys. J., **741**, 82 (14pp)
Tisserand, F.-F. (1896) *Traité de Mécanique Céleste IV* (Gauthier-Villars, Paris)
Tokovinin, A. A. (1997) "On the multiplicity of spectroscopic binary stars." Astron. Lett., **23**, 727–730
Tokovinin, A. (2014) "From binaries to multiples. II. Hierarchical multiplicity of F and G dwarfs." Astron. J., **147**, 87 (14pp)
Tokovinin, A., Thomas, S., Sterzik, M., & Udry, S. (2006) "Tertiary companions to close spectroscopic binaries." Astron. Astrophys., **450**, 681–693
Tremaine, S., Touma, J., & Namouni, F. (2009) "Satellite dynamics on the Laplace surface." Astron. J., **137**, 3706–3717
Trujillo, C. A., & Sheppard, S. S. (2014) "A Sedna-like body with a perihelion of 80 astronomical units." Nature, **507**, 471–474
Van Laerhoven, C., & Greenberg, R. (2012) "Characterizing multi-planet systems with classical secular theory." Celest. Mech. Dyn. Astron., **113**, 215–234
Vashkovyak, M. A. (1981a) "Evolution of orbits in the restricted circular twice-averaged three-body problem. I — Qualitative investigations." Cosmic Research, **19**, 1–10
Vashkovyak, M. A. (1981b) "Evolution of orbits of asteroids not belonging to the main belt." Cosmic Research, **19**, 357–365
Vashkovyak, M. A. (1982) "Evolution of orbits in the two-dimensional restricted elliptic twice-averaged three-body problem." Cosmic Research, **20**, 236–244
Vashkovyak, M. A. (1984) "Integrable cases of the restricted twice-averaged three-body problem." Cosmic Research, **22**, 260–267
Vashkovyak, M. A. (1986) "An investigation of the evolution of some asteroid orbits." Cosmic Research, **23**, 255–267
Vashkovyak, M. A. (1999) "Evolution of the orbits of distant satellites of Uranus." Astron. Lett., **25**, 476–481
Vashkovyak, M. A. (2001) "Orbital evolution of Saturn's new outer satellites and their classification." Astron. Lett., **27**, 455–463
Vashkovyak, M. A. (2003) "Orbital evolution of new distant Neptunian satellites and ω-librators in the satellite systems of Saturn and Jupiter." Astron. Lett., **29**, 695–703
Vashkovyak, M. A. (2005) "Particular solutions of the singly averaged Hill problem." Astron. Lett., **31**, 487–493

Vashkovyak, M. A., & Teslenko, N. M. (2008a) "Evolution characteristics of Jupiter's outer satellites." Sol. Sys. Res., **42**, 281–295 [Erratum: Sol. Sys. Res., **43**, 463]

Vashkovyak, M. A., & Teslenko, N. M. (2008b) "Evolutionary characteristics of the orbits of outer Saturnian, Uranian, and Neptunian satellites." Solar Sys. Res., **42**, 488–504 [Erratum: Sol. Sys. Res., **43**, 464]

Veras, D., & Evans, N. W. (2013) "Exoplanets beyond the Solar neighbourhood: Galactic tidal perturbations." Mon. Not. R. Astron. Soc., **430**, 403–415

Veras, D., Crepp, J. R., & Ford, E. B. (2009) "Formation, survival, and detectability of planets beyond 100 AU." Astrophys. J., **696**, 1600–1611

von Zeipel, H. (1916) "Recherches sur le mouvement des petites planètes." Ark. för Mat., Astr. och Fys., **B. II**, H. 1, 1–58

Wan, X.-S., & Huang, T.-Y. (2007) "An exploration of the Kozai resonance in the Kuiper Belt." Mon. Not. R. Astron. Soc., **377**, 133–141

Webbink, R. F. (1984) "Double white dwarfs as progenitors of R Coronae Borealis stars and Type I supernovae." Astrophys. J., **277**, 355–360

Welsh, W. F., Orosz, J. A., Carter, J. A., Fabrycky, D. C., Ford, E. B., *et al.* (2012) "Transiting circumbinary planets Kepler-34b and Kepler-35b." Nature, **481**, 475–479

Wen, L. (2003) "On the eccentricity distribution of coalescing black hole binaries driven by the Kozai mechanism in globular clusters." Astrophys. J., **598**, 419–430

Whitmire, D., Matese, J., Criswell, L., & Mikkola, S. (1998) "Habitable planet formation in binary star systems." Icarus, **132**, 196–203

Williams, J. G. (1969) "Secular perturbations in the solar system." Ph. D. thesis (Univ. of California, Los Angeles)

Williams, J. G., & Benson, G. S. (1971) "Resonances in the Neptune–Pluto system." Astron. J., **76**, 167–177

Williams, J. G., & Faulkner, J. (1981) "The positions of secular resonance surfaces." *Icarus*, **46**, 390–399

Winn, J. N., Fabrycky, D., Albrecht, S., & Johnson, J. A. (2010) "Hot stars with hot Jupiters have high obliquities." Astrophys. J., **718**, L145–L149

Winn, J. N., Johnson, J. A., Albrecht, S., Howard, A. W., Marcy, G. W., Crossfield, I. J., *et al.* (2009) "HAT-P-7: a retrograde or polar orbit, and a third body." Astrophys. J., **703**, L99–L103

Wright, J. T., Fakhouri, O., Marcy, G. W., Han, E., Feng, Y., Johnson, J. A., Howard, A. W., Fischer, D. A., Valenti, J. A., Anderson, J., & Piskunov, N. (2011) "The exoplanet orbit database." Publ. Astron. Soc. Pacific, **123**, 412–422

Wu, Y., & Murray, N. (2003) "Planet migration and binary companions: The case of HD 80606b." Astrophys. J., **589**, 605–614

Wu, Y., Murray, N. W., & Ramsahai, J. M. (2007) "Hot Jupiters in binary star systems." Astrophys. J., **670**, 820–825

Xie, J.-W., Payne, M. J., Thébault, P., Zhou, J.-L., & Ge, J. (2011) "Planet formation in highly inclined binary systems. I. Planetesimals jump inward and pile up." Astrophys. J., **735**, 10 (18pp)

Zapatero Osorio, M. R., Béjar, V. J. S., Martín, E. L., Rebolo, R., Barrado y Navascués, D., Bailer-Jones, C. A. L., & Mundt, R. (2000) "Discovery of young, isolated planetary mass objects in the σ Orionis star cluster." Science, **290**, 103–107

Zhuravlev, V. F., & Klimov, D. M. (1988) *Applied Methods in the Theory of Oscillations* (Nauka Publishers, Moscow) (in Russian)

Ziglin, S. L. (1975) "Secular evolution of the orbit of a planet in a binary-star system." Sov. Astron. Lett., **1**, 194–195

Zinnecker, H. (2001) "A free-floating planet population in the Galaxy?" In: ASP Conf. Series, **239**, 223–228

Index

J_2 harmonic, 51
N-body problem, 16, 64
γ Cep system, 139, 146
ω-libration, 5, 58, 60, 87, 133
ω-librators, 61
Interbol, 11
Kepler (space mission), 141, 145, 151
Kepler-16, 145
Kepler-34, 145
Kepler-35, 145
Kepler-38, 145
Kepler-47, 145
Luna-1, 6
Luna-3, 1, 9, 77, 111
Prognoz, 11
SOHO (space mission), 105
Spektr-R, 11, 77
"man-made LKE", 9
"polar Moon", 7
16 Cyg system, 139, 146
2012 VP113 (ETNO), 131
51 Peg system, 148

accretion disk, 166
action-angle variables, 18
adiabaticity parameter, 86
advance of perihelion, 52
Alpha Centauri, 141
Amor group, 39
Ananke group, 96
angular momentum, 35
anomalous precession, 52
aphelion, 3
apoapse, 3
apoastron, 3
apogee, 3
apsidal precession, 52, 53
argument of pericenter, 4
ascending node, 4
asteroids, 59, 118, 122
astrocentric position vector, 32
astronomical constants, 175
astronomical parameters, 175
astronomical unit of length, 175
asymptotic period, 89
autonomous Hamiltonian system, 16
averaged Hamiltonian, 41
averaged variables, 71
averaging, 13, 19, 32, 58, 59, 64
averaging scheme, 28
axial rotation, 53
axisymmetric potential, 48

ballistic existence, 11, 77
barycentric frame, 2, 15, 106, 107
binary asteroid, 144
binary exoplanet, 144
binary stars, 63
binary TNO, 144
Birkhoff normal form, 21, 25
black hole, 161, 164
blue stragglers, 162, 164
brown dwarfs, 141

C/1965 S1 Ikeya–Seki, 114
Callisto, 96

I. I. Shevchenko, *The Lidov-Kozai Effect – Applications in Exoplanet Research and Dynamical Astronomy*, Astrophysics and Space Science Library 441,
DOI 10.1007/978-3-319-43522-0

canonical equations, 72
canonical transformation, 31, 87
canonical variables, 14
capture, 94
Carme group, 96
Carpo, 98
Cartesian frame, 3, 41, 48
catastrophic merger, 76
Centaurs, 59, 118, 131
Chandrasekhar limit, 162, 164
chaotic diffusion, 65
chaotic layer, 84, 159
Charon, 55
choreographies, 63
Cincinnati, 39
circular R3BP, 58, 60, 61, 76, 87, 106, 151
circular restricted three-body problem, 110, 131
circumbinary planets, 145
circumstellar planets, 145
classification of orbits, 36, 64
close approach, 110
close encounter, 117, 126
close-to-coplanar triples, 74
comet 1965 VIII Ikeya–Seki, 105
comet Ikeya–Seki, 112
comet Lovejoy, 112
compact binary, 47
computer algebra, 20
contour-level diagrams, 58
criterion of resonance overlap, 84
critical angle, 60, 84
critical argument, 60, 84
critical inclination, 34, 37, 38, 58, 61, 133
critical radius, 54
critical semimajor axis, 55
crossings of orbits, 58
curly π, 5
cyclic variables, 19, 64, 73

D'Alembert rules, 29, 60, 101, 119, 135
dark side of the Moon, 9
degenerate transformation, 73
Delaunay variables, 13, 17, 18, 33, 41, 44, 64, 69, 87, 120
descending node, 4
diffusion timescale, 159
direct perturbation, 16
distant encounter, 108
dogleg angle, 4
double-averaged circular R3BP, 57, 77
double-averaged elliptic R3BP, 62
double-averaged general 3BP, 62, 64
double-averaged Hamiltonian, 32
double-averaged Hill approximation, 62
double-averaged non-restricted 3BP, 62
double-averaged R3BP, 31, 35, 57
double-averaged rectilinear R3BP, 57
DP Leo, 145
dynamical chaos, 84, 115, 156, 158

Earth, 52, 59, 76, 175
Earth mass, 175
Earth perturbation, 76
Earth radius, 175
Earth-grazer, 111
eccentric anomaly, 3
eccentric LK-mechanism, 61, 76, 79, 81, 163
eccentricity vector, 81
ecliptic plane, 95
ecliptic-to-equator obliquity, 175
effective dissipation parameter Q, 50
Einstein, 52
elimination of nodes, 65, 69, 72
ellipsoid, 175
elliptic integral of the first kind, 44, 77, 78, 82, 89, 122, 153
elliptic integral of the second kind, 45, 82, 153
elliptic integral of the third kind, 44
elliptic integrals, 78
elliptic R3BP, 42, 45, 61, 76, 151
epoch of the pericenter transit, 3
equal-mass binary, 81
equations in partial derivatives, 22, 25
equatorial orbit, 37
eugenfrequency, 111
Euporie, 93, 96, 98
extreme trans-Neptunian objects (ETNO), 130

fast variables, 13, 19
first fundamental model of resonance, 88
flip timescale, 82
forced eccentricity, 134, 142
Fourier series, 22, 25
free-floating planets, 140, 144
FS Aur, 145

Galactic center, 162, 166, 167
Galactic disk tide, 115
Galactic field, 115, 168
Galactic plane, 169
Galactic tide, 46, 106, 113–115, 168, 169
Galaxy, 63, 166, 167
Gallic group, 99

Ganymed, 39
gas drag, 94
gas giant, 51
gas-drag capture, 94
Gauss–Kronrod algorithm, 58
general 3BP, 65
General Assembly of the International Astronomical Union, 175
general problem of dynamics, 13
general relativity, 52, 54, 67, 76, 80, 150
general three-body problem, 62, 107, 143, 152, 163
generating function, 21, 24–26, 70
generating Hamiltonian, 24
generator, 24, 26
geocentric frame, 15
giant exoplanet, 53
giant planet, 31, 53
giant planets, 91
globular clusters, 63
gradient operator, 15
gravitational constant, 175
gravitational manoeuvre, 10
gravitational scattering, 149
gravitational wave radiation, 165, 167
gravity assist, 9, 10
Great Comet of 1965, 105
Great March comet, 112

Halimede, 93, 102
Hamiltonian equations, 16, 18, 34, 69
Hamiltonian formalism, 14
heliocentric frame, 15
Heuman Lambda function, 45
hierarchical approximation, 52
hierarchical multiple stars, 162
hierarchical stellar three-body problem, 62
hierarchical three-body problem, 142
hierarchical three-body system, 62
hierarchical triple, 65, 67
hierarchical triples, 64
Hildas, 60
Hill approximation, 28–30
Hill problem, 30, 57
Hill radius, 30, 56, 92
Hill sphere, 30, 91
Himalia group, 96
homologic equation, 25
Hori–Deprit method, 20, 23, 62, 70
hot Jupiters, 50, 52, 53, 139, 148, 149, 151
hot Neptunes, 139
HW Vir, 145
Hydra, 55, 56

Ijiraq, 93, 99, 101
inclination gap, 96
indirect perturbation, 16
inner LKE, 122
inner planets, 145
inner problem, 58, 62
inner R3BP, 122
integrability, 64
integrable approximation, 21
integral of motion, 28, 31, 33, 35, 82
integrals of motion, 60
interaction Hamiltonian, 32
interaction of resonances, 85
interaction potential, 35
interaction term, 67
Inuit group, 99
invariable plane, 64, 65, 69, 70, 72
inverse Hill problem, 57
irregular satellites, 91, 94

Jacobi constant, 106, 108
Jacobi elliptic functions, 28, 41, 43
Jacobi frame, 65, 67, 69
Jacobi integral, 65, 106, 108
Jacobi matrix, 73
Jacobi nome, 45
James (asteroid), 118, 136
Jovian system, 96
Jupiter, 51–53, 126, 129, 175

Kepler equation, 3
Kepler map, 110
Kepler's third law, 48
Keplerian Hamiltonian, 32, 65, 66
Keplerian orbital elements, 2
Keplerian term, 67
Kerberos, 55
kinetic energy, 16
Kirkwood gaps, 60, 134
Kiviuq, 93, 99, 101
Kore, 98
Kozai (asteroid), 45
Kozai diagram, 114, 121
Kozai Hamiltonian, 121
Kreutz sungrazers, 112
Kuiper belt, 59, 117, 127, 129, 131

Lagrange equations, 35
Lagrange planetary equations, 50, 134
Lagrange–Laplace theory, 6, 64, 118
Laomedeia, 45

Laplace plane, 6, 54, 96
Laplace radius, 54, 92
Laplace vector, 81
Legendre polynomials, 48, 68
Lenin prize, 10
Lidov-Kozai diagram, 39
Lidov-Kozai Hamiltonian, 27, 31, 33, 62, 87
Lidov-Kozai migration, 140, 148
Lidov-Kozai resonance, 5, 27, 34, 37, 39, 46, 56, 61, 77, 83, 111, 126, 137
Lie operator, 24
Lie series, 24
Lie techniques, 23, 24
Lie transformation, 26
light pressure, 94
Lindstedt method, 20
linear resonance, 84
Lomonosowa, 61
long-period comets, 58, 113
longitude of pericenter, 4
Love number, 50, 51
Ludovica, 61
Lunar perturbation, 76
Lyapunov timescale, 159

main belt of asteroids, 59, 122, 129, 131, 134
main-belt asteroids, 38, 39, 60
main-sequence stars, 145
Margaret, 102, 103
Mars, 52
mass loss, 67
mass transfer, 67, 80
massless particle, 16, 34
mean elements, 46
mean longitude, 5
mean motion resonance, 60, 142
mean motion resonances, 132
mean variables, 71
Mercury, 47, 52, 126, 140
migration, 140, 148
Milky Way, 166
mixed variables, 70
modified Delaunay variables, 18
Moon, 76, 91, 175
multiplanet systems, 140, 141, 143
multiple stars, 161, 162
multipole expansion, 68

Near-Earth Object (NEO), 39
near-integrable system, 13, 19
Neptune, 52, 61, 129, 131, 175
Neptune XII, 45
Neptunian system, 101
Nereid, 102
Neso, 103
neutron star, 161, 163, 164
Nix, 55
NN Ser, 145
node crossings, 126, 129, 131
non-autonomous system, 17
non-averaged general 3BP, 65
non-canonical transformation, 73
non-hierarchical circular R3BP, 58
non-restricted problem, 77
non-sphericity, 47, 54
nonlinear resonance, 84
normalization, 20, 23, 26, 32, 64, 70
normalized Hamiltonian, 71, 72
normalizing transformation, 20, 24, 26
Norse group, 99
notations, 171
numerical integration, 72, 75

oblateness, 46, 150, 175
octupole approximation, 62, 67, 75
octupole Hamiltonian, 67, 68, 71, 81
octupole term, 74, 81, 151, 154, 163
octupole-order approximation, 64
octupole-order equations, 73
octupole-order Hamiltonian, 64
omega-libration, 5
Oort cloud, 46, 106, 113, 114, 130, 168, 169
orbit correction, 11
orbital flips, 62, 76, 80, 151, 152, 154, 163
orbital precession, 46, 134
ordinary differential equations, 14
Orion nebula, 140
orphan planets, 140
orthogonal apsidal orbits, 57
osculating elements, 17, 32–34, 46, 68
outer LKE, 122
outer planets, 145
outer problem, 58
outer R3BP, 122
outer Solar system, 58

P-type planets, 145
Paaliaq, 99, 101
Pallas, 6
parametric resonance, 87
parsec, 175
Pasiphae group, 96
pendulum, 84
pendulum model of resonance, 84, 87
periapse, 3

periastron, 3
perigee, 3
perihelion, 3
period of LK-oscillations, 44, 45, 53–55, 77
perturbation techniques, 67
perturbative approach, 19, 23, 76
perturbing function, 28, 29, 35, 58, 134, 142, 151
phase portrait, 84
phase space section, 84, 86
planar elliptic R3BP, 57
planar restricted three-body problem, 141
planet-crossings, 58
planet-grazer, 111
planet-planet scattering, 144
planetary *N*-body problem, 64
planetary 3BP, 64
planetary formation, 146
planetary problem, 19, 118
planetary satellite, 28, 30, 31
planetary systems of binary stars, 145
planetesimal disks, 143, 146
planetesimals, 146
planetocentric elements, 28
planets of the Solar system, 48, 92
plutinos, 118, 133
Pluto, 55, 61, 118, 133, 175
Pluto–Charon binary, 55
Pluto–Charon system, 56
Poisson bracket, 23
polar orbit, 37
potential, 15, 108
potential energy, 16
power series, 24, 32
precession rate, 48, 52, 53, 143
primordial binaries, 63
primordial matter, 106, 113
prograde orbits, 92
proper elements, 134
proper frequency, 134
pull-down capture, 94
pulsar, 164

quadruple stars, 144
quadrupole approximation, 29, 31, 74, 77–79
quadrupole Hamiltonian, 68, 73, 74, 78, 79
quadrupole term, 81
quadrupole-order approximation, 64
quasi-parabolic comets, 58

R3BP, 13, 34, 65, 77, 89
rectilinear orbit, 37, 38
reference plane, 32, 70
regular islands, 129
regular satellites, 92
relativistic precession, 47, 52, 166
resonance ν_5, 117, 118, 132, 134
resonance ν_6, 117, 132, 134
resonance ν_{16}, 61, 118, 134, 136, 137
resonance 1/1, 60
resonance 2/1, 60, 117, 124, 132, 134
resonance 2/3, 61
resonance 3/1, 60, 117, 132, 134
resonance 3/2, 60
resonance 4/3, 60
resonance 5/2, 124
resonance 7/3, 60
resonance overlap, 84, 142, 156
resonance triplet, 86
resonant angle, 60, 101
resonant argument, 60, 84
resonant phase, 84
restricted 3BP, 64
restricted problem, 19, 31
restricted three-body problem, 13, 48, 83, 106, 107
retrograde orbits, 92, 94, 140, 151
Roche-lobe overflow, 166
rogue planets, 140
Rossiter–McLaughlin effect, 150, 151
rotational oblateness, 53

S-stars, 166
S-type planets, 145
S0-stars, 166
Sao, 93, 102, 103
Saturn, 51–53, 129, 175
Saturnian system, 99
second fundamental model of resonance, 88
second order resonance, 88
secular resonance, 61, 83, 133–135
secular theory, 31
secular timescale, 143
selenocentric frame, 15
self-gravity, 146
semiproper inclination, 136
separatrix, 38, 42, 77, 79, 84, 89, 115, 126, 137, 159
separatrix map, 110
short-period comets, 58
Siarnaq, 99
single-averaged problem, 28
single-averaged R3BP, 28, 35, 36
slow angles, 60
slow variables, 13

Solar mass, 175
Solar neighborhood, 161, 163
Solar oblateness, 47
Solar perturbation, 76
Solar radius, 175
Solar system, 30, 31, 47, 48, 64
Solar-type star, 51, 163
Solar-type stars, 63, 161
Space era, 6
space mission design, 77
spatial elliptic R3BP, 57
speed of light, 175
stellar bulge, 162, 167
stellar clusters, 63
stellar disks, 162, 166
stellar evolution, 67
stellar passage, 115
stellar problem, 67
stellar three-body problem, 62
stellar triple, 31, 62
Styx, 55
subscript system, 67
Sun, 175
sungrazer, 105, 113
sungrazing comets, 58
super-Earth, 131
supermassive black hole (SMBH), 166, 167
supernovae, 162, 164
Svea, 61
SWEEPS-04, 141
SWEEPS-11, 141
symplectic unity, 73
synchronous state, 53
synodic frame, 107
SZ Her, 145

Taylor series, 68
test particle, 31, 32
test particle limit, 78
test-particle quadrupole approximation, 73
Themisto, 98
theory of accelerators, 87
third fundamental model of resonance, 88
tidal bulge, 51–53
tidal circularization, 151, 163
tidal friction, 149
tidal interaction, 47, 55
tidal precession, 50
tides, 50, 53, 54, 67, 76, 80, 149, 150
tight binary, 50, 161, 162
tightly-packed planetary system, 149
timescale of eccentric LK-mechanism, 80
timescale of LK-oscillations, 76, 80
Tisserand parameter, 109
Tisserand relation, 106, 109
total energy, 16
trans-Neptunian objects (TNO), 59, 117, 118, 122, 127
transformation close to identity, 13, 20
triple stars, 63, 144, 161–164
Triton, 102
Trojans, 60
twin stars, 163
two-body problem, 15, 16, 18

Uranian satellites, 28, 46
Uranian system, 101
Uranus, 28, 46, 52, 129
UZ For, 145

valence of transformation, 73
Venus, 48, 52, 59, 132
von Zeipel method, 20, 21, 23, 32, 60, 62, 64, 70, 71

WASP-12b, 53
Weierstrass elliptic functions, 41
white dwarf, 161, 163, 164

zonal harmonics, 48