COMMISSION 7 : CELESTIAL MECHANICS (MÉCANIQUE CELESTE)

Report of Meetings, 18 and 24 August 1994

ACTING PRESIDENT : S. Ferraz-Mello
SECRETARY : A. Milani

Business Meetings

1. Election of Organizing Committee

The commission elected the following officers and members of the Organizing Committee for the term 1988 to 1991:

President:	S.Ferraz-Mello
Vice-President	Cl.Froeschlé
Members:	R.Dvorak
	K.Kholshevnikov
	H.Kinoshita
	J.H.Lieske
	A.Milani
	J.C.Muzzio
	S.Peale
	A.E.Roy
	M.Soffel
	A.G.Sokolsky
	Y.-S. Sun

2. Election of New Members of the Commission

The following IAU members were proposed as new members of Commission 7 and were approved after a short presentation: M. Amar (Algeria), J. Anosova (ussia), G. Beutler (Sziwtzerland), A. Boss (USA), P. Hut (USA), D.N.C. Lin (USA), L. Martinet (Switzerland), J.C. Muzzio (Argentina), A. Ollongren (Netherlands), M. Sato (Brazil), J. Souchay (France), W. Thuillot (France), S. Tremaine (USA), M. Tsuchida (Brazil) & V. Zhdanov (Ukraine).

The proposals were done by the National Committees or by Commission members present at the General Assembly.

3. Working Group on Nutation

In the first session, Dr. B.Kolaczek, president of IAU Commission 19 invited Commission 7 to join Commissions 4 and 19 to organize a joint Working Group on Non-Rigid Earth Nutation. The Commission discussed and approved the creation of such Working Group. Dr. J. Souchay was indicated to represent Commission 7 in the Working Group.

I. Appenzeller (ed.), Transactions of the International Astronomical Union Volume XXIIB, 131-134.

TABLE 1 Parameters of the PSR B1257+12 planetary system

Orbital parameters and masses	A	B	C
Semi-major axis (light ms)	0.0035(6)	1.3106(6)	1.4121(6)
Eccentricity	0.0	0.0182(9)	0.0264(9)
Epoch of periastron (JD)	2448754.3(7)	2448770.3(6)	2448784.4(6)
Orbital period (s)	2189645(4000)	5748713(90)	8486447(180)
Longitude of periastron (deg)	0.0	249(3)	106(2)
Planet mass ($M_\oplus$)	$0.015/\sin i_1$	$3.4/\sin i_2$	$2.8/\sin i_3$
Distance from the pulsar (AU)	0.19	0.36	0.47
Orbital period (days)	25.34	66.54	98.22

Detailed analyses of the dynamics of the PSR B1257+12 planetary system and their effects on pulsar timing have been carried out by Malhotra (1993), Rasio *et al.* (1993) and Peale (1993). The observable consequences of a mutual gravitational interaction between planets B and C include near-resonant (3:2), periodic variations of the elements of their orbits and the superimposed short-term, non-resonant fluctuations.

In timing observations, the perturbations manifest themselves in the form of oscillating residuals, if the least-squares fit of a timing model to data assumes fixed-parameter, non-interacting orbits. These oscillations are characterized by timescales of the order of orbital periods of the planets and by amplitudes which depend on the planet-to-pulsar mass ratios. Compared to a timing model without planetary perturbations (Table 1), inclusion of this effect in the modelling process reduces the value of χ^2 for the global fit by nearly 3%, which is about 50 times the formal accuracy of the minimization procedure. The detection of planetary perturbations represents a proof that the pulse arrival time variations observed in PSR B1257+12 are due to orbital motion of planet-mass bodies with the dynamical characteristics that are not unlike those of the inner planets of the Solar System. A more detailed description of the above analysis can be found in Wolszczan (1994).

Pulsars accompanied by planets can be used as highly accurate probes of planetary dynamics. In the case of PSR B1257+12, a positive identification of planetary perturbations and the detection of a Moon-mass planet A involved measurements and analysis of pulse arrival times at a microsecond precision level, which is equivalent to radial velocity resolution of the order of 1 mm s^{-1} (factor of 10^4 better than the typical 10 m s^{-1} resolution achieved in modern single-line Doppler spectroscopy). Evidently, detections and dynamical studies of terrestrial-mass planets will remain beyond the reach of optical astrometry and Doppler spectroscopy in the foreseeable future, but they will be quite feasible with the pulse timing method.

References

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RECENT ADVANCES IN RELATIVISTIC CELESTIAL MECHANICS

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In addition to the review on progress in relativistic Celestial Mechanics included in Commission 7 triennial report (*IAU Transactions*, **22A**, 15), it is reasonable to indicate some points where this progress may be beneficial for other domains of Celestial Mechanics:

1. *Mathematical foundation of the approximation methods.* Schäfer (1993) gave a very clear comparative analysis of post-Minkowskian and post-Newtonian approximation schemes and underlined the role of the ADM (Arnowitt-Deser-Misner) coordinates for mathematically rigorous treatment of the field equations in Celestial Mechanics problems.

2. *Lagrangian and Hamiltonian formulation of the relativistic equations of motion.* Schäfer (1991) developed an elegant technique of reduction of higher time-derivative Lagrangians occurring in relativistic celestial mechanics. The Hamiltonian of the relativistic two-body problem in ADM coordinates taking into account the gravitational radiation terms is given also by Schäfer (1993). Blanchet and Schäfer (1993) have investigated the gravitational wave tails in binary star systems.

3. *Development of* DD *(Damour-Deruelle) parametrization.* Schäfer and Wex (1993) extended the DD parametrization of the Keplerian two-body problem for the relativistic two-body problem in the post-post-Newtonian approximation succeeding to present the final results in rather compact form. The equivalence of different kinds of post-Newtonian parametrization was demonstrated by Klioner and Kopejkin (1994).

4. *Relativistic dynamics of Earth's rotation.* As shown by Brumberg (1994) the global baricentric equations of Earth's rotation derived long ago seemed to be useful when transforming to geocentric expressions for Earth's angular rotation velocity and Earth's quadrupole moments. Relativistic dynamical corrections to Earth's rotation may be practically ignored in using the geocentric dynamically non-rotating reference system.

New important results were obtained also in domains as the relativistic theory of reference systems and time scales, the relativistic reduction of astronomical observations and the relativistic satellite equations of motion in barycentric and geocentric reference systems, and were described in the Commission 7 report. One may conclude that most problems of practical importance belonging to these domains have been solved in the post-Newtonian approximation.

References

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