COMMISSION No. 7

CELESTIAL MECHANICS (MECANIQUE CELESTE)

Reports of meetings on August 4 and 8

PRESIDENT: V.Brumberg
SECRETARY: S. Ferraz-Mello

BUSINESS MEETING

A business session was held on August 4. A second brief meeting was held on August 8. Items addressed were:

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

President:	J.Henrard
Vice President:	A.Deprit
Members:	K.B.Bhatnagar
	V.A.Brumberg (Past President)
	J.Chapront
	S.Ferraz-Mello
	Cl.Froeschlé
	J.D.Hadjidemetriou
	K.Kholshevnikov
	H.Kinoshita
	He Miaofu
	A.Milani
	A.E.Roy
	P.K.Seidelmann

2. Election of New Members of the Commission
The National Committees have requested that the following new members of IAU become members of Commission 7 and they were approved after a short presentation: A.J.Abad (Spain), E.L.Akim (USSR), L.E.Doggett (USA), G.Dourneau (France), L.Duriez (France), R.S.Gomes (Brazil), Cheng Huang (China), P.Kammeyer (USA), J.Klokocnik (Czechoslovakia), J.Laskar (France), J.J.Lissauer (USA), T.Pauwels (Belgium), S.Segan (Yugoslavia), V.I.Skripnichenko (USSR), M.L.Sein-Echaluce (Spain), J.R.Taborda (Portugal), A.L.Whipple (USA), T.Yokoyama (Brazil) and B.Zafiropoulos (Greece).

3. Consultants
The Commission elected the following consultants for the term 1988-1991: V.I.Arnold (USSR), K.Meyer (USA), J.Moser (Switzerland), D.Saari (USA), S.K.Shrivastava (India), C. Simo (Spain), M. Soffel (German F.R.), J.Waldvogel (Switzerland) and J.Wisdom (USA).

4. Deceased Members
The commission payed tribute to the memory of Professors G.N.Duboshin, P.E.Elyasberg, O.C.Mohler and A.A. Orlov, members of the commission deceased since the past General Assembly.

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5. Recommendations of Working Groups.

Dr. J.Kovalevsky presented to Commission 7 the motion of the Working Group on the theory of Nutation to correct the 1980 nutation series. He also presented the package of motions of the Working Group on Reference Frame proposing the adoption of a celestial reference frame made of a consistent set of coordinates of a sufficient number of extragalactic objects.

6. Recommendations of the joint meeting of Commissions 4, 7, 8, 19, 24, 31 and 40.

Dr. J.Kovalevsky presented the recommendation issued of the joint meeting For Milliarcsecond or Better Accuracy of fusion of the Working Groups on Nutation, Reference Frame and Astronomical Constants in just one working group, the Working Group on Reference Systems, whose work would be divided in 4 study groups: Nutation, Astronomical Constants Origin and Time.

7. The journal CELESTIAL MECHANICS

The commission has been advised that the Celestial Mechanics Institute has elected Professor Jacques Henrard as the next Executive Editor of the journal. Prof. Henrard will be in charge after January 1st., 1989, when other editorial changes will be announced. The commission expressed its gratitude to Professor Morris Davis for the excellent work done during his term as executive editor.

SCIENTIFIC SESSIONS

Six invited review papers were presented in the sessions held on August 8:

A. The Few Body Problem (M.Valtonen)
B. Stability of the Solar System (A.Milani)
C. Chaotic Behaviour (J.Wisdom)
D. Evolutionary Problems (S.J.Peale)
E. Ring Dynamics (N.Borderies)
F. Secular Resonances in the asteroid belt (Ch.Froeschlé).

The following abstracts were provided by the lecturers. Full length papers will be published in *Celestial Mechanics*.

STABILITY OF THE SOLAR SYSTEM (A.Milani)

A significant improvement in our understanding of the problem of the stability of the solar system resulted from the notion of regular conditionnally periodic orbits inextricably mixed with chaotic and escape orbits. A realistic perspective of solution of the problem must therefore rely on the estimate of the difference between a KAM-type orbit and the real motion over a finite time span. The achievement of such goal meets huge difficulties in all the computational procedures. In the development of analytical theories it is not any more possible to ignore the small divisor problem and the divergence of the perturbative series as a practical - not only theoretical - computational difficulty, while KAM theories do not provide a constructive algorithm. Numerical integration cannot yet directly answer questions over the stability of a realistically modelled solar system over a timescale comparable to its real age; extrapolation beyond the computed interval are not possible within a rigorous framework. Nevertheless, long term integrations by numerical and seminumerical methods of the outer planets over $10^8 - 10^9$ years (LONGSTOP, digital orrery) and of the inner planets over $10^6 - 10^7$ years (Laskar, Richardson) have greatly extended the timespan over which the dynamical behaviour of the planets is understood. The interpretation of these results is not easy because indications of a non regular behaviour have been detected, e.g., in the spectrum and in the proper modes of both, the LONGSTOP and the Laskar integrations, but the extent of the macroscopic changes which might be associated with the

non regular behaviour is not known.

SECULAR RESONANCES IN THE ASTEROID BELT (Ch.Froeschlé)

According to analytic theories a secular resonance occurs if the orbital precessional rate of an asteroid is equal to one of the eigenfrequencies of the system of planetary orbits in the frame of secular perturbations theory. The old linear theory, valid only for small eccentricities and inclinations, was improved in 1969 by Williams whose theory is valid for high eccentricities and inclinations and also yields the location of secular resonances in the proper elements space. New theories by Nakai and Kinoshita (1985) and by Yoshikawa (1987), for the resonance ν_{16} and ν_6, as well as recent numerical experiments give quantitative results on the variations in eccentricity and inclination. They also allow us to investigate the topological structure of secular resonance and the possible chaotic character of secular resonant motions.

RING DYNAMICS (N.Borderies)

1. *Observational discoveries by Voyager concerning the rings of Uranus*: Voyager 2 discovered a tenth narrow ring between the rings ϵ and δ, a broad faint inner ring located approximatively 1500 km inside the innermost narrow 6 ring, a continuous distribution of small particles throughout the Uranus ring system and 10 new satellites orbiting near the rings. 2. *Resonances in the Uranian rings*: 1986 U7 and 1986 U8 are the shepherd satellites of the ϵ ring; 1986 U7 is the outer shepherd of the δ ring, and is a shepherd of the tenth ring discovered by Voyager, 1986 U1R; 1986 U8 is the outer shepherd of the γ ring (Porco amd Goldreich, *Astron.J.***93**, 724, 1987 and French *et al., Icarus***73**, 349, 1988). 3. *Shapes of the Uranian rings*: Most of the rings of Uranus are best fitted by inclined elliptical ring models corresponding to a normal mode m=1. However, the γ ring contains, in addition to the mode $m = 1$, the mode $m = 0$, which means that it undergoes radial oscillations with a frequency equal to the epicyclic frequency, and the delta ring is best fitted by the mode $m = 2$, which means that it has the shape of an ellipse centered at the planet (French *et al., Icarus***73**, 349, 1988). 4. *Problems with the self-gravity model in the Uranus rings*: The self-gravity model allows us to explain how elliptical narrow rings can maintain their shape in terms of a balance between effects due to the oblateness of the planet and effects due to the self-gravity (Goldreich and Tremaine, *Astron.J.***84**, 1638, 1979 and Borderies, Goldreich and Tremaine, *Astron.J.***88**, 1560, 1983). This model encounters serious difficulties with the rings α and β (Marouf, Gresh and Tyler, *Bull.AAS***19**, 883, 1987). 5. *Arcs of rings around Neptune*: A natural explanation for incomplete rings around Neptune, as revealed by recent occultation observations (Hubbard *et al., Nature***319**, 636, 1986), is that they consist of arcs of particles librating around a corotation resonance. Two models were presented (Lissauer, *Nature***318**, 544, 1985 and Goldreich, Tremaine and Borderies, *Astron.J.***92**, 490, 1986). 6. *Possibility of polar rings around Neptune*: Because of the presence of Triton, a satellite of Neptune with an unusual orbit in that sense that it is very inclined although close to the planet, rings with high inclinations are possible around Neptune (Dobrovolskis, *Icarus* **43**, 222 1980 and Borderies, to appear in *Icarus*). Preliminary results indicate that such rings would be stable (Dobrovolskis, Steiman-Cameron and Borderies, research in progress). 7. *Formation of sharp edges by shepherd satellites*: A recent model of the shape of perturbed streamlines near an edge maintained by a close satellite faithfully reproduces the sharp edges which bound the Encke division. It is found that this striking feature is related to the local reversal of the viscous transport of angular momentum in the most strongly perturbed regions (Borderies, Goldreich and Tremaine, submitted to *Icarus*).