

**BEHAVIOR OF OBSERVED ASTEROIDS IN THE NEIGHBORHOOD OF THE 3: 1  
RESONANCE**

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The number of observed asteroids in the neighborhood of the 3: 1 resonance has been increasing significantly over the last years. In 2002 this number was 2.7 times as high as in 1999. This resonance is one of the main sources of NEAs (Near-Earth Asteroids). Several observational campaigns, specially Spacewatch Programs, are being undertaken in order to identify new NEAs. The list of unstable observed asteroids in the 3: 1 neighborhood when the 2002 data is added to the 1999 Bowell data is also increasing. Asteroids have been selected for numerical integration (for  $10^8$  years with Venus to Saturn included) according to a previously adopted approach with the Planar Restricted Three-Body Problem. It is based on a representative plane which allows an estimated border of the 3: 1 resonance. The positions of the selected asteroids in this plane are bounded by contour curves and those obtained from them by adding 0.01AU on both sides outside the resonance. The number of unstable asteroids increased from 20 in the old sample to 54 in the updated sample. It is interesting to note that both numbers correspond to about 40% of the total number in each sample. When asteroids inside the contour curves are not considered, we obtain an exponential decay for the time variation of the number of surviving unstable asteroids in the range  $10^6$  to  $10^8$  years. The sample is not complete so in the future we will possibly obtain a more representative sample and a better understanding of the removal process by chaotic diffusion in the neighborhood of the 3: 1 resonance.

**COERÊNCIA ESPECTROSCÓPICA DE FAMÍLIAS DE ASTERÓIDES**

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As Famílias de asteróides são caracterizadas como agrupamentos de objetos provenientes da quebra por colisão de corpos precursores. Desta forma, seus membros devem preservar relações genéticas que podem ser traduzidas sob a análise de suas características espectrais. Neste trabalho é apresentado o primeiro estudo espectroscópico de todas as famílias de asteróides do cinturão principal. Para tal, a divisão em famílias foi refeita utilizando-se o método HCM com uma base de elementos próprios analíticos (Knezevic e Milani, Jun 2001) e para o estudo espectroscópico foram utilizadas diversas campanhas de observação espectroscópica, tais o S3OS2 e o SMASSII, bem como outros dados disponíveis na literatura. A homogeneidade espectroscópica de cada família foi

avaliada através da verificação das classes espectroscópicas presentes, bem como da comparação destes espectros com os de objetos de fundo, localizados na vizinhança da família. Vinte e duas famílias foram analisadas (as que possuíam mais do que 3 membros com espectro) e, dentre as principais conclusões pode-se citar a homogeneidade espectroscópica e, provavelmente mineralógica das famílias de Vesta, Eunomia, Hoffmeister, Dora, Merxia, Agnia, Koronis e Veritas. Esta última em particular, foi tida como uma família não homogênea espectroscopicamente em trabalho anterior (Di Martino et al. 1997). Outro resultado interessante é, por um lado, a aparente falta de homogeneidade dos membros da família de Eos, e por outro sua forte distinção dos objetos de fundo. O oposto ocorre na família de Themis, esta apresentando-se espectroscopicamente compatível com os objetos de fundo, mas com grande homogeneidade taxonômica entre seus membros. Algumas das famílias apresentam asteróides “intrusos” (objetos cujas características físicas não são compatíveis com aquelas dos membros da família) que, de modo geral desaparecem ao se considerarem níveis mais baixos de corte para a divisão da família no HCM, sem prejuízo para o agrupamento dos demais membros.

PAINEL 267

**THE LIMITS OF VESTA FAMILY: A DYNAMICAL AND MINERALOGICAL  
ANALYSIS OF THE VESTA REGION**

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It has been known for a long time that asteroid 4 Vesta presents a crust of basaltic composition. This object is also the main member of the largest asteroidal family in the inner asteroid belt: the Vesta family. The fact that most of the members of the dynamical family with known chemical properties are composed of basalts, –so called V-type asteroids–, and the discovery of the large crater (~450 km) on the surface of Vesta, led to the conclusion that Vesta family was originated on a large cratering event. However, there are several recently identified V-type asteroids that, from the dynamical point of view, do not belong to the Vesta family. This fact raised the question about the origin of such basaltic bodies. There are two possible explanations: (i) they are not related to the same cratering event that formed the Vesta family, or (ii) they were fugitives from the family and arrived to their present locations due to some dynamical mechanism. In this work, we have analyzed this last possibility. First, we have re-determined the Vesta family using the recently updated proper elements database provided by Milani and Knežević (<http://hamilton.dm.unipi.it/astdys>). This new family has been compared to the sample of the known V-type asteroids (<http://www.daf.on.br/lazzaro/S3OS2-Pub/s3os2.htm>). We have found that there are about 20 V-type asteroids that do not belong to the Vesta family. Then, we have performed a detailed dynamical study of the phase space around 4 Vesta, using the direct numerical simulations and the spectral analysis method. We have detected a dense presence of weak two- and three-body

mean motion resonances and secular resonances in this region, and analyzed their effects, together with the effect of Yarkovsky forces, on the long term evolution of the actual and fictitious objects. The results indicate that both mean-motion and secular resonances may transport the asteroids outside the Vesta family. However, the dynamical times needed to deliver the objects under question to their present locations, are too large if compared to the estimated age of the family. Also, the effect of Yarkovsky forces is only relevant over very long time scales. In view of this, we need to find other scenarios to explain the existence of the V-type asteroids outside the Vesta family.

PAINEL 268

## DYNAMICS OF COORBITAL SYSTEMS IN THE PLANAR ELLIPTIC CASE

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The simplicity of the three body problem in its various forms has attracted the attention of mathematicians for centuries. Among the giants of mathematics who have tackled the problem and made important contributions are Euler, Lagrange, Laplace, Jacobi, LeVerrier, Hamilton and Poincaré. Szebehely's (1967) book provides an important coverage of the literature on the subject as well as derivations of important results. When the third body is too small to affect the motion of the other two bodies, the problem of the motion of the third body is called the restricted three body problem. In the restricted three body problem, the motion of the primaries must satisfy the differential equations that describe the dynamics of two gravitational bodies. Consequently, the primaries might describe elliptic, parabolic or hyperbolic orbits. The case, when the primaries move on circles, gives a general definition to simplify its development. However, it is a particular case and to carry out a more realistic study, elliptical motion of the primaries must be introduced. The generalization of this case is not trivial: while the restricted circular problem of three bodies still possesses the Jacobi integral, the elliptic problem does not. This property of the elliptic problem distinguishes it from the circular problem and indicates the increased degree of difficulty involved in solving it. The circular problem presents the well known Lagrangian equilibrium points. Due to the structure of the phase space there are two families of stable coorbital orbits known as tadpole and horseshoe. The main objective of the present study is to evaluate how the effects of the eccentricity of the primaries can affect the stability of these coorbital trajectories. Therefore, in this study we show how the elliptic problem can be formulated and numerical simulations are made using the pulsating coordinates system to determine how the eccentricity of the primaries orbits change the stability of horseshoe and tadpole orbits. Our results show that the amplitude of oscillation increases for orbits around L4 and decreases for orbits around L5.

PAINEL 269

## COMETA HYAKUTAKE (C/1996 B2): ANÁLISE DO GÁS E CARACTERÍSTICAS FÍSICAS DAS PARTÍCULAS DE POEIRA.

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A completa caracterização e compreensão do núcleo de um cometa novo é de fundamental importância para a elucidação dos processos físicos e químicos atuantes na época da formação do Sistema Solar. O Cometa Hyakutake, conjuntamente com o Cometa Hale-Bopp representam os objetos mais brilhantes que visitaram o Sistema Solar Interno nos últimos 20 anos. Neste Trabalho, nós aplicamos o Método Semi-Empírico das Magnitudes Visuais (MSEMV) à aproximadamente 4000 dados observacionais que correlacionam a magnitude visual absoluta com a distância heliocêntrica para o Cometa Hyakutake nas fases pré- e pós-periélicas. Como produto da aplicação desse método, conseguimos caracterizar dimensionalmente seu núcleo e área ativa efetiva. As taxas de produção dos radicais CN, C2 e C3, obtidos a partir de dados disponíveis na literatura, revelam que, além de muito brilhante, o Hyakutake é um cometa "normal" no sentido de Cochran (1986). Desse modo, deduzimos as taxas de perdas de água (em moléculas/s) a partir da análise de sua magnitude visual aparente, e as convertimos em taxas de perdas de gás (em g/s), desprezando pelo núcleo cometário. Com o auxílio do modelo fotométrico clássico da poeira, realizamos uma análise sistemática e uniforme dessa componente cometária, a partir dos fluxos observacionais no contínuo, para os comprimentos de onda 365,0 e 484,5 nm, assumindo que esses fluxos são o resultado da radiação solar espalhada por grãos de partículas micrométricas presentes na coma. Com isso, pudemos obter as taxas de produção (em g/s), cores (relativas à cor neutra solar), e as dimensões efetivas médias das partículas de poeira, bem como as razões poeira-gás.

PAINEL 270

## FORMATION OF KUIPER BELT BINARIES BY RECOIL

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Recent observations have discovered that over one percent of the known Kuiper belt objects are binaries. Besides this high population, these binaries are formed by comparable mass components with large separations between them. Such systems have defied models to account for their formation based on restricted three-body interactions. Among current theories, some consider that they could be produced by collisions of planetesimals within the Hill sphere of a hosting body during the low velocity accretion of the solar nebula. The collision of the two bodies results in their accretion. This and the hosting body then forms a binary. Others believe the usual projectile-target formation mechanism which is believed to have formed the Moon-Earth system. Some others ponder close gravitational interactions, not collisions, of two bodies to form a transient binary

which could be stabilized through dynamic friction from the surrounding medium or through scattering of a third large body (planet) that happens to be there. To account for the unique features of Kuiper belt binaries, we consider the gravitational interactions of two comparable masses  $s$  and  $G$  under the field of the central Sun  $S$ . Since the two masses are comparable, they will react on each other and generate recoil on their orbits, contrary to the restricted three-body interactions. By considering angular momentum and energy conservations, it is shown that part of the  $S$ -centered relative angular momentum between  $s$  and  $G$  before encounter can be transferred to the orbital angular momentum of the  $sG$  pair leaving a small enough  $S$ -centered angular momentum to be converted into a stable  $G$ -centered mutual angular momentum of the  $sG$  binary. The energy of this binary system measured with respect to its orbital energy is so close to zero that the separation between the components is large which is consistent with observations. This recoil mechanism operates under a constraint that links the mass ratio of the components to their  $S$ -centered relative angular momentum before encounter. Nevertheless, this mechanism falls short in accounting for the Charon-Pluto pair.

PAINEL 271

### **COULD PRESSURE EFFECTS CAUSE THE DISCONNECTION EVENTS IN COMETS?**

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Cometary and solar wind data are compared with the purpose of identifying the solar wind conditions which are associated with comet plasma tail disconnection events (DEs). The cometary data are from *The International Halley Watch Atlas of Large-Scale Phenomena*. A systematic visual analysis of the atlas images revealed, among other morphological structures, 47 DEs along the plasma tail of comet P/Halley. The solar wind are *in situ* measurements from IMP-8, which are used to construct the actual variation of solar wind speed, density and dynamic pressure during the analyzed intervals. This work compares the onsets of these DEs with the solar wind dynamic pressure variations in order to clarify if pressure effects play an important role in the formation of DEs and if they can even be considered as the triggering mechanism. The analysis however reveals a poor correlation (23%) between the onsets of P/Halley's DEs and the associated pressure effects. This result is in good agreement with Wegmann (1995) who concluded in an independent and theoretical analysis, that about 25% of all tail disconnections must be caused by interplanetary shocks. The DEs onsets of comet P/Halley analyzed in this work, calculated from observational data, do not corroborate the idea that DEs are associated with dynamic pressure effects.