Title : will be set by the publisher
Editors : will be set by the publisher
EAS Publications Series, Vol. ?, 2002

SPIN-ORBITAL EVOLUTION OF EXOPLANETS

Alexander Gusev and Irina Kitiashvili[1]

Abstract. We investigated the equation describing the evolution of the kinetic momentum vector of planets by the action of gravitational and magnetic interaction. The obtained gallery of portraits of the kinetic momentum evolution illustrates the various regimes of planetary system evolution. We are going to investigate a fine structure of protoplanetary disk around the pulsar by VLTI for detection of extrasolar planets on early time of formation.

1 Gallery of the exoplanets and Phase portraits of the spin-orbital evolution

Among all of the extra-solar planets (Schneider 2002) may be classified in the following way: according to mass - 75 planets have the same mass as Jupiter; 2 - as planet with Earth mass and 2 as the Moon; 8 exoplanet systems contain more than one planet (PSR 1257+12 - 4 planets, ε Andromedue - 3 planets, HD 83443 - 2 planets and Gliese 876 - 2 planets). Typical representatives of planets within different classification groups are given in Table.

In 1992 A. Wolszczan and D.A. Frail discovered a planetary system around the pulsar PSR 1257+12 with a period of a 6.2-millisecond (Wolszczan & Frail 1992). The system is the most interesting and "rich" by number of planets (A, B, C and D; Table), Two of them, B and C, move in the resonance 3:2. At the present time the question whether there exist another three pulsars in the planetary systems is under discussion: PSR 0329+54 (1 planet), PSR B1620-26 (1 planet) and PSR 1828-11 (3 planets).

The discovery extra-solar planets request details investigations questions of dynamical evolution of the planetary systems on early stage forming planets the most value have gravitational and tidal interaction. Dust disks around stars still retain information about the formation processes of the exoplanetary systems as they are formed by collisions of planetesimals or protoplanets. Large eccentricity

[1] Depts. of Astronomy and Geophysics, Kazan University, Russia;
e-mail: `Alexander.Gusev@ksu.ru & Irina.Kitiashvili@ksu.ru`

DOI: (will be inserted later)

Table 1. Masses and orbital characteristics of exoplanets

Stars	$M sin(i), M_J$	a, AU	$P, days$	e
ε Andromedue	0,71	0,059	4,617	0,034
	2,11	0,83	241,2	0,18
	4,61	2,5	1266,6	0,41
51 Peg	0,47	0,05	4,2293	0
ε Eridani	0,86	3,3	2502,1	0,608
PSR B1257+12	0,015 $M_\oplus$	0,19	25,34	0,0
	3,4 $M_\oplus$	0,36	66,54	0.0182
	2,8 $M_\oplus$	0,47	98,22	0.0264
	0,005 $M_\oplus$	–	1278	–

of the exoplanets by need to pump up by subsequent interactions (Boss 2001). The process of planetary formation is significantly determined by the orbital-rotational characteristics of the planet. At the early stages of planet evolution the tidal interaction takes a principal role: the tidal effects lead to the capture into resonance rotation of the planets (as example PSR B1257+12 - 2:3, HD 82943 - 1:2, Gliese 876 - 1:2), even if the initial rotation was non-resonance one.

The planet will be considered as a dynamically symmetrical celestial body magnetized along the symmetry axis, its rotation being nonresonant. According to Beletsky and Khentov (1995), under the total perturbation from gravitational and magnetic moment, the following equations describe the evolution of the vector L. We shall obtain the dynamical system (Gusev & Kitiashvili 1999):

$$\dot{x} = -\alpha \sin y \qquad \dot{y} = \beta - \alpha ctgx \cos y + \gamma \cos x.$$

Here α , β,γ are parameters of gravitational and magnetic interaction.

The equations, describing the nonresonant rotation are investigated by using qualitative analyses and bifurcation methods. The obtained dynamical system may be naturally considered on the two-dimensional sphere. As result of the investigation, paramet ers α , β,γ disperse over the area and a different topological structure is obtained, and the gallery of more than 17 phase portraits is constructed. These portraits illustrate all possible evolution scenarios of planetary systems. The analyses of obtained portraits have demonstrated a possibility for a planet reverse from a direct rotation and vice versa for a rather broad range of the parameters. We have calculated the determinant of the dynamical system in the first approximation as relative to x. The bifurcation curve $\Delta = 0$ is presented in Fig. 1a. The maximum point A (0,1) of the bifurcation curve corresponds to the gallery of 17 phase portraits and the points $A1(\sqrt{2}, 0)$ and $A2(-\sqrt{2}, 0)$ correspond to the gallery of 8 phase portraits, analysed in Kitiashvili & Gusev (2000). Phase portrait, corresponding to the parameters values are shown in Fig. 1b on the phase sphere.

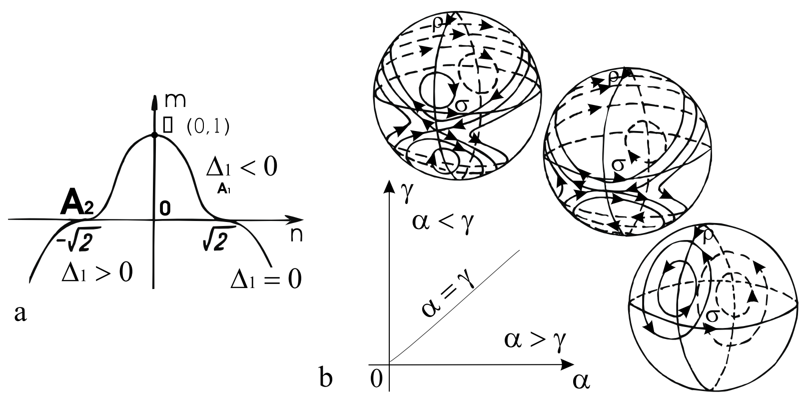

Fig. 1. a. Bifurcation cover in the first approximation with $\Delta = 0$ and b. Gallery of phase portraits

There are four stationary points, three of them are of center kind and one - of saddle kind. When the vector of kinetic moment comes nearer to an equilibrium state, its motion will have type of precession with a constant angular distance with periodical variation of the rotation from direct into reverse one.

2 Looking up of protoplanetary disks around of neutron stars

Within the next decade the European Southern Observatory's Very Large Telescope Interferometer (VLTI) will employ visible and near-infrared interferometers in the hunt for planets. Interferometers are important tools in the planet hunt because they eliminate light from distant stars so that astronomers can look for unseen planets that may be orbiting them (Paresce 2001). We hope to obtain the reflection spectrum of planets in sufficient detail to determine main atmospheric constituents, thermodynamical history of planets around main sequence stars and neutron stars for our improved understanding of planetary properties. We would like to investigate a fine structure of protoplanetary disk around the optic pulsar for detection of extrasolar planets on early time of formation in frames of VLTI for combination of observed periodic delays in the arrival times of pulsar pulses.

References

Beletsky, V.V. & Khentov, A.A. 1995, *"Resonance rotation of celestial bodies"*, 430 pp.

Boss, A.P. 2001, *Proc. of Int. Conf. "ASTROKAZAN 2001"*, Kazan Univ., p.87-93

Gusev, A. & Kitiashvili, I. 1999, *Proc. of Conf. "GeomPhys IV"*, Kazan Univ., p.115-123

Kitiashvili, I. & Gusev, A. 2000, Exoplanets, *Georesources*, v.3, p. 26-30

Paresce, F. 2001, *Proc. of Int. Conf. "ASTROKAZAN 2001"*, Kazan Univ., p.248-249

Schneider, J. 2002, *The Extrasolar Planets Encyclopaedia*, http://www.obspm.fr/planets

Wolszczan, A. & Frail, D.A. 1992, *Nature*, 355, p. 145