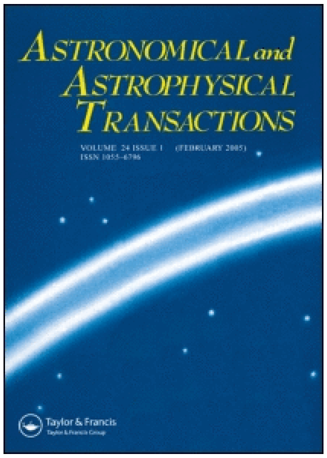

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

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Online Publication Date: 01 January 1994
To cite this Article: Fridman, A. M. and Gor'kavyi, N. N. (1994) 'On the possibility of detection of massive planets in protoplanetary disks', Astronomical & Astrophysical Transactions, 5:1, 249 - 251
To link to this article: DOI: 10.1080/10556799408245876
URL: http://dx.doi.org/10.1080/10556799408245876

Astronomical and Astrophysical Transactions, 1994,
Vol. 5, pp. 249–251
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ON THE POSSIBILITY OF DETECTION OF MASSIVE PLANETS IN PROTOPLANETARY DISKS

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(Received November 3, 1993)

A massive planet (300–500 $M_\oplus$) in the circumstellar disk of β Pictoris at 5–10 AU from the central star is predicted. The method of the detection of this planet by both Hubble Space Telescope and ground based telescopes is proposed.

KEY WORDS Planets, proplanet disks

1 INTRODUCTION

The star β Pictoris (visual magnitude 3.85, spectral class A5V, mass 2 $M_\odot$, radius 1.75 $R_\odot$, luminosity 10 $L_\odot$ and distance 18 pc) has an extended gas-dust ring from 100 AU to 500 AU discovered by the IRAS team (Smith and Terrile, 1984, Beust *et al.*, 1989). The ratio of the disk thickness to the disk radius is 1/6, which implies the inclinations of 5° or less of most of the disk particle orbits to the plane of the disk (hence, the orbital eccentricities of the particles are less than 0.1).

The detection of the absorption in some metallic ion lines of the UV spectrum performed by IUE Satellite (Beust *et al.*, 1989) Goddard High Resolution Spectrograph in Hubble Space Telescope (News Release, 1991) revealed one more gaseous disk with a radius of several AU around β Pictoris. Transient redshifts of metallic lines in UV show compact gaseous clumps falling towards β Pic with radial velocities sometimes reaching 300 or 400 km s^{-1}. These clumps may be perhaps treated as a result of evaporation of hundreds of comets, falling towards β Pic every year (Beust *et al.*, 1989). The existence near the star of many of bodies with orbital eccentricities close to unity requires for its explanation the presence of a planetary or protoplanetary body in the disk.

The authors have put forward the hypothesis (Fridman and Gor'kavyi, 1991) that a giant planet β Jupiter (analogous to Jupiter) with a mass of 300–500 $M_\oplus$ is being formed near β Pic at a distance of 5–10 AU. The estimate of β Jupiter's mass bases on the assumption that the ratio of the disk mass to the stellar mass and the mass distribution in the region of 5–10 AU are approximately the same as in the solar system. The probability of existence of a closer planet to β Pic is small because of the presence of a gaseous disk. But in a more distant region than 5–10 AU a giant planet grows much slower. It is known (Safronov, 1972), that in the course of the formation of giant planets a large number of planetesimals are thrown away from the zone of the planet growth. A part of these planetesimals and comets falls towards β Pic, causing a sharp change in UV spectrum. A large part of planetesimals is adsorbed by the gaseous disk, thus increasing its mass.

It is impossible to detect β Jupiter by means of the reflected stellar light, but perhaps the Hubble Space Telescope can detect the zone of the planet growth which has a lower density and about 5 AU wide (or 0.3 arcsec). It is possible to detect β Jupiter directly at the presence of the significant own luminosity of β Jupiter. According to modern cosmogonic models, proto-Jupiter had a temperature 5000 K and its luminosity reached 0.003 $L_{\odot}$. If the hypothetical β Jupiter is in the analogous stage of a violent accretion, then its luminosity can reach 0.01–0.001 $L_{\odot}$. This means that β Jupiter will look like a star with a maximum visual magnitude of 11–13.5 at a distance of 0.3–0.6 arcsec from β Pic (without a possible absorption of the light in the dust disk).

2 THE SUBJECT OF OBSERVATIONS

The aim of observations is the registration of rapid changes in the spectrum of β Pictoris' type stars due to the falling of asteroid size bodies towards β Pic star. In particular, integral changes (amplifications) of the absorption lines of calcium ions K and H CaII with wavelengths 3933.66 Å and 3968.47 Å are observable with ground-based telescopes. As indicated by previous observations of β Pictoris, the typical time of the spectrum change is several hours, the typical frequency is several hundred events a year. Therefore it is important to observe the spectrum change in the course of a few hours at a time and to repeat such sessions as frequently as possible to obtain a long series of observations. A search for a similar reversal of spectra is essential to all stars, where we can expect the existence of gas-dust disks. Such changes of the spectrum can serve as a reliable indicator of the availability of a disk and the formation of planets in it (weakly dependent on the disk orientation).

3 DATA TREATMENT. ANALYSIS OF INITIAL MATERIAL

This analysis contains the following:

1) the identification of spectral lines, measurement of the red shift and determination of the line-of-sight velocity of ions;

2) the determination of all radiation components (semi-stationary radiation of halo and disk, high-variable radiation of falling bodies);

3) the analysis of the temporal sequence of spectrum changes as a result of every event (in the falling of one body);

4) the estimation of the typical size and density of the absorption cloud of ions, forming in evaporation of a falling body;

5) the account for radiation absorption in the stellar atmosphere, in disk and in the interstellar medium.

4 THE CONSTRUCTION OF THEORETICAL MODEL

A rather detailed theoretical model can be constructed according to the assumption on the existence of a massive planet in the disk of asteroidal bodies near β Pic star. In the framework of this model, the connection between the frequency of the falling of asteroidal bodies, the planetary mass, its distance from the β Pic star and the density of planetesimal disk can be easily established. The more parameters of the falling bodies will be known from the initial analysis of observation, the stronger connection and with a large number of parameters of the hypothetical planet can be predicted. It is not inconceivable that there is a periodicity in the frequency of the change of the spectrum, connected with the period of the orbital rotation of the planet. Our numerical model for the 3-dimensional analysis of the trajectories of bodies scattered from the giant-planet makes possible to relate parameters of the giant-planet and falling bodies to observational data. Let us note that the growth of the few scattering centers can lead to the same observational appearance as for a big center (Vityazev, 1993). Discovery of new circumstellar disks and young planets is of prime consideration.

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