# The variable circumstellar extinction in protoplanetary disks with embedded companions

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## 1 Introduction

Periodic perturbations in the circumstellar disk, caused by the orbital motion of the companion, produce streams of matter, spiral density and shock waves ([1, 2] and others). If the orbit is not coplanar with the disk the inner part of the disk is warped [3]. All these features can affect on the circumstellar extinction and propagation of the star radiation to an observer.

## 2 Model and calculation method

Here we consider the model of an young star with the low-mass companion ($q \leq 0.1$) embedded in the protoplanetary disk. We research two cases: 1) the orbit of the companion is eccentric one, but coplanar to the disk plane (Fig. 1, 2) 2) the orbit is circular and slightly inclined to the disk plane ($\alpha \leq 10°$) (Fig. 3). We calculated the set of the hydrodynamic models of such systems using our modification of GADGET 2 code [4, 5].

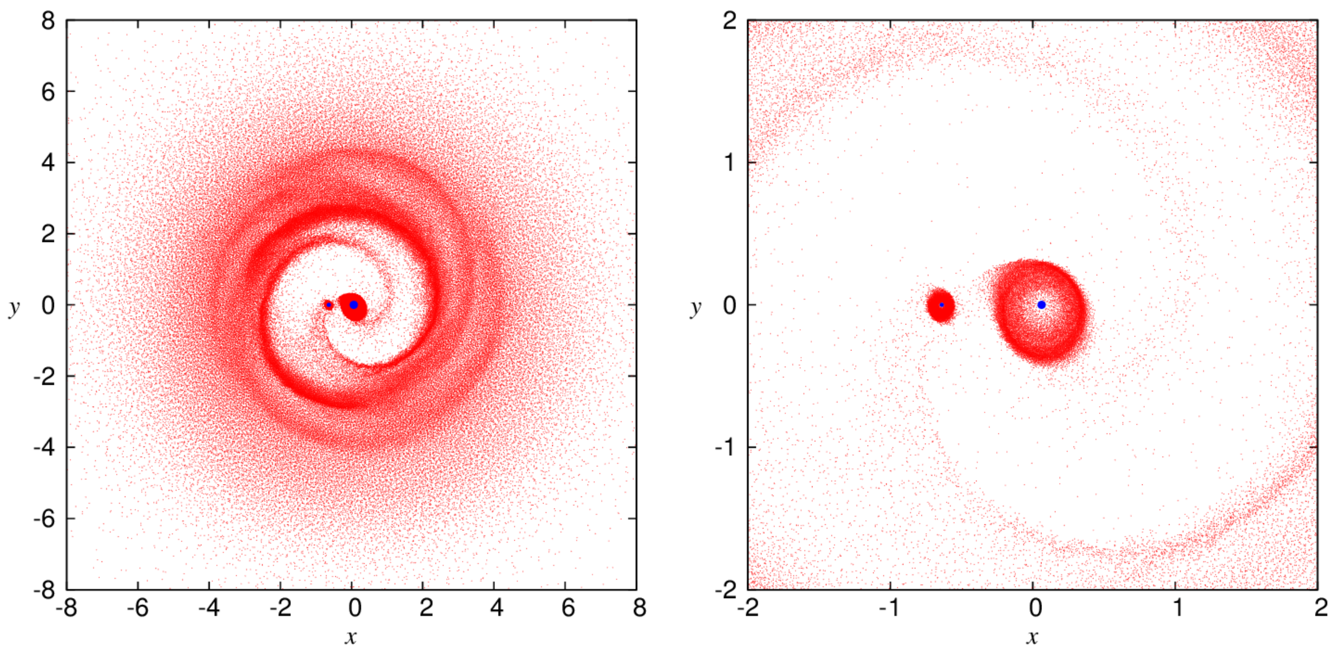


Figure 1: The matter distribution in the disk after 10 convolutions of the companion (left) and the inner part of one (right). The model parameters are $e = 0.3$, $\alpha = 0°$, the mass ratio $q = M_2 : M_1 = 0.1$. The distances (on $x, y, z$ axis) are in units of the semi-major axis of the companion ($a$).

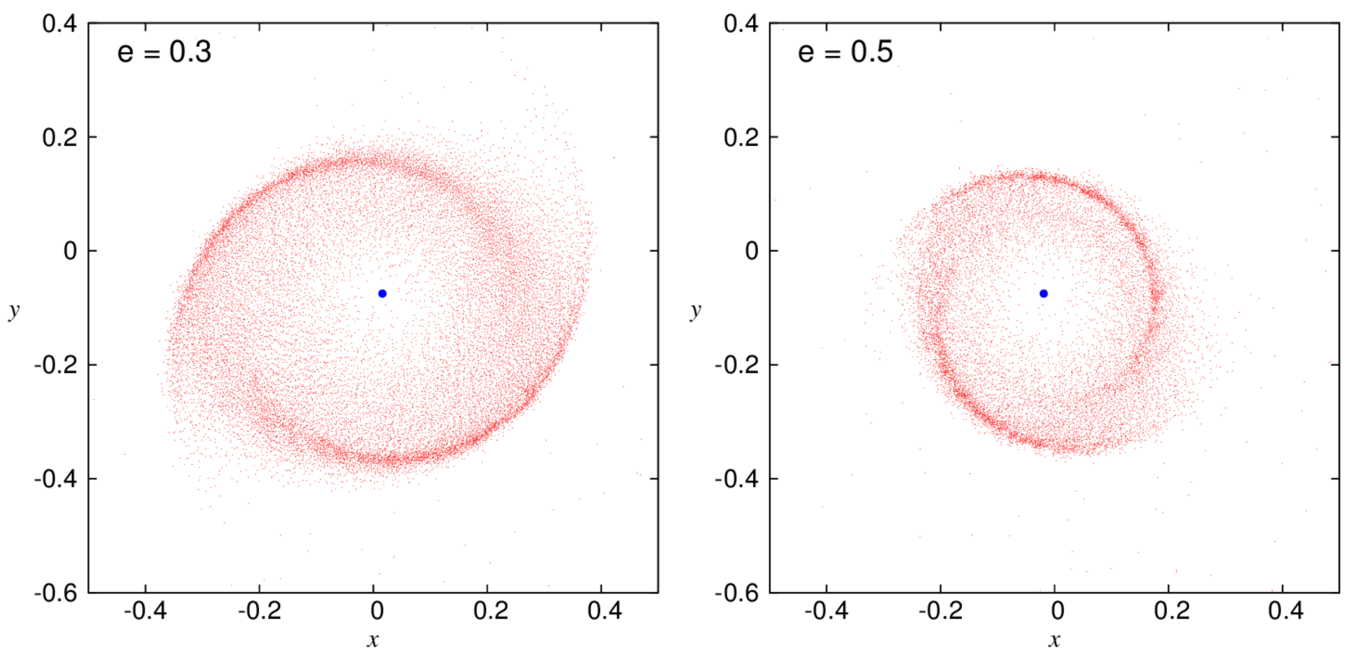


Figure 2: The disk around the star for two models $e = 0.3$ and $e = 0.5$, $q = 0.1$ for both models

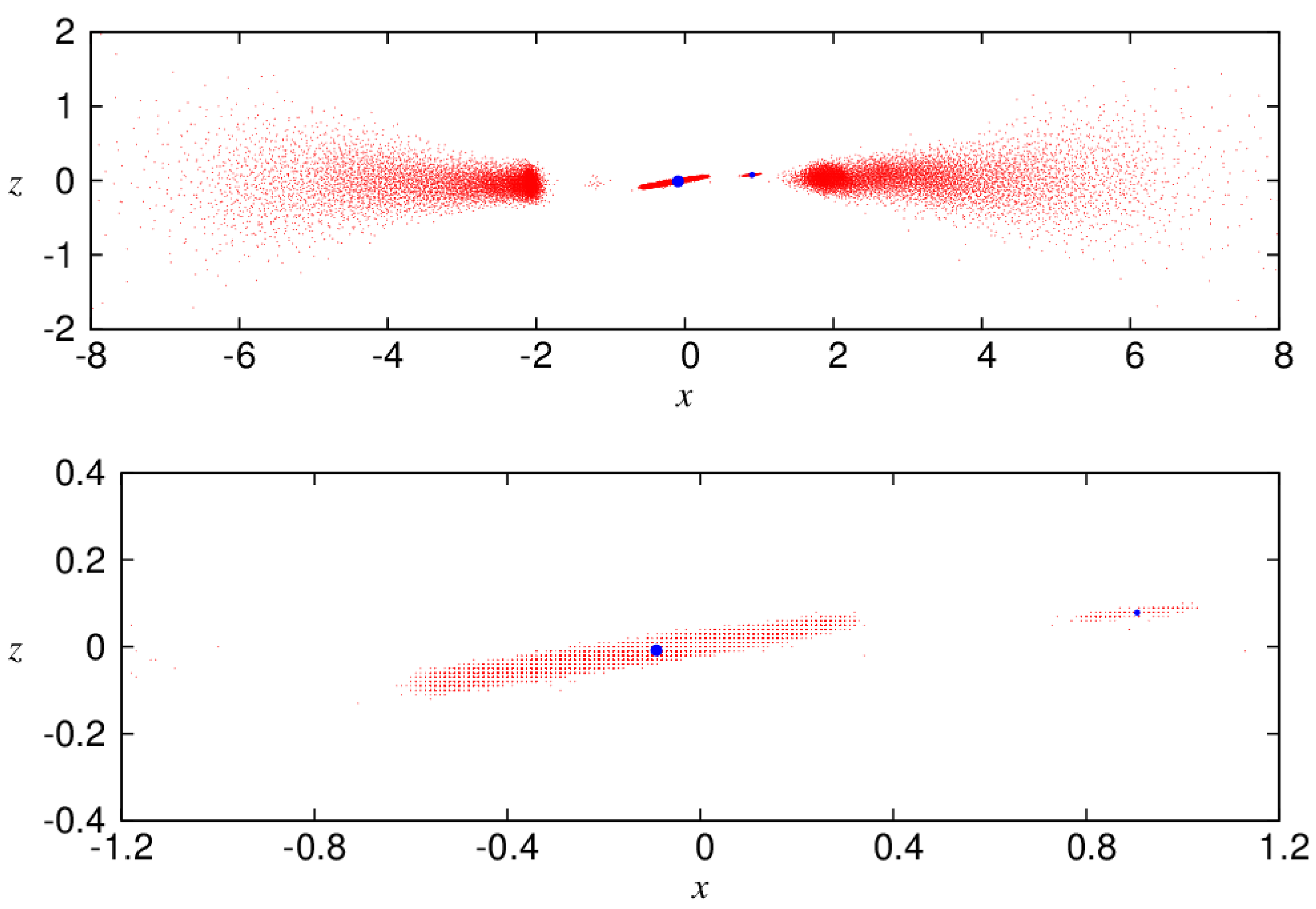


Figure 3: The section of the inclined model in $x, z$ plane (top) and the inner part of one (bottom). The model parameters are $e = 0$, $\alpha = 5°$, $q = 0.1$.

## 3 Results

If we observe the circumstellar disk near to the edge-on the orbital motion of the companion can lead to the periodic variations of CS extinction of the young star. It can lead to the cyclic activity on the brightness curves of UX Ori type stars [6, 7] (Fig. 4). If the orbit of the planet incline to the disk plane in some direction one can see the transit of the companion disk on the star (Fig. 5).

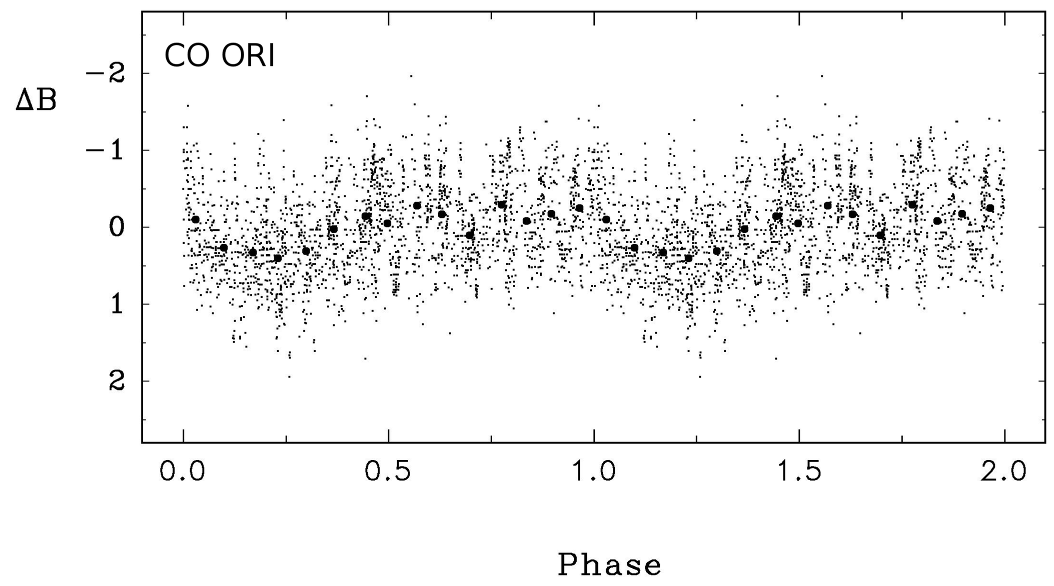


Figure 4: The B-band light curve of CO Ori folded with a period of 12.4 yr based on data from [8].

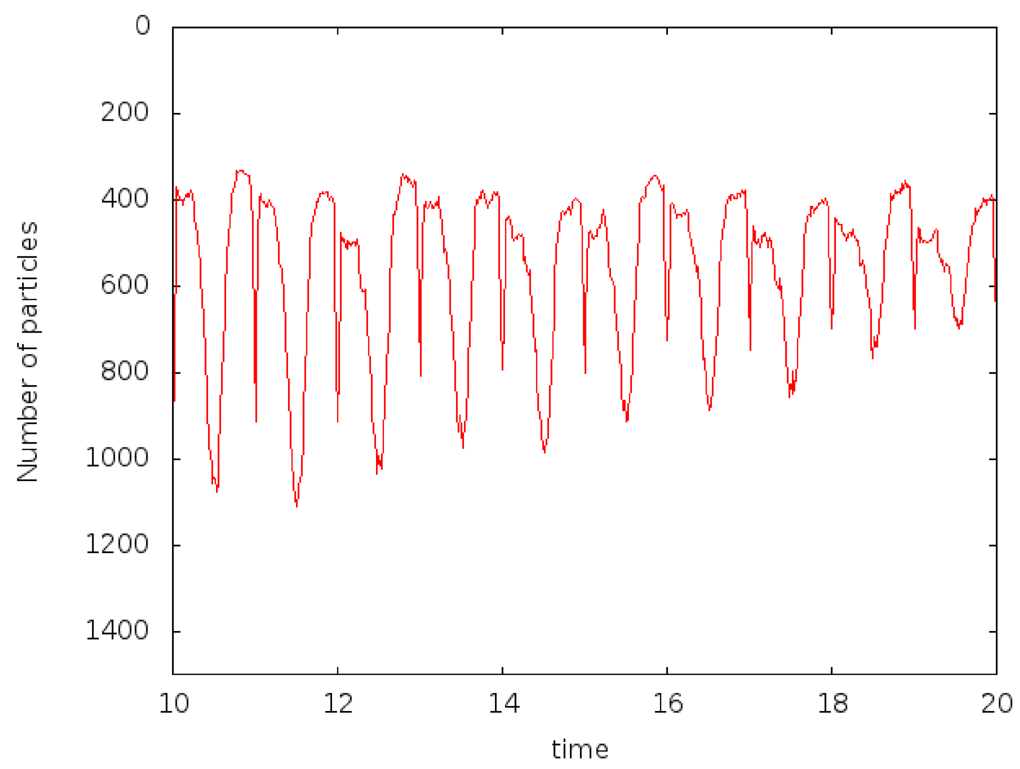


Figure 5: The theoretical light curve in the model with inclined orbit for the case when the line of sight intersects the orbit. The wide minima are caused by the periodic changes of extinction in outer part of disk. The narrow minima are the transits of the companion disk on the star.

We also research variations of the accretion rates with a phase of the orbital period (Fig. 6)

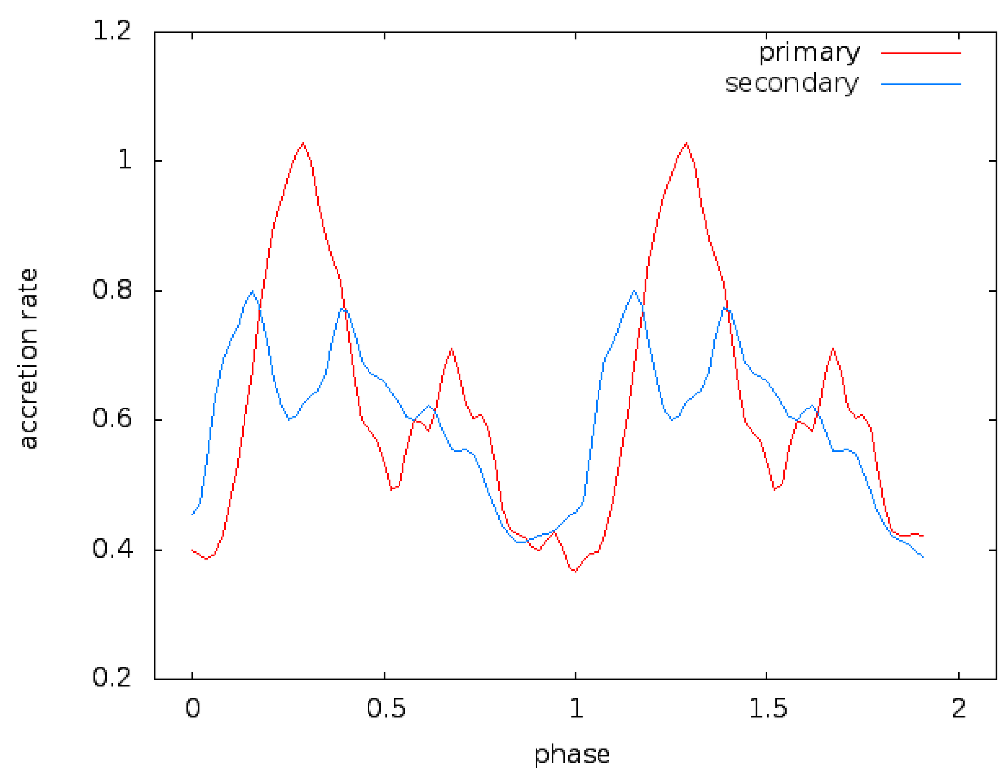


Figure 6: The accretion rate on the star (red) and companion (blue) in the inclined model (Fig. 3)

The properties of our models open new opportunities of searching low-mass companions in the circumstellar disks of the young stars.

We are preparing the paper with the details of the calculations. The work are supported by Committee on Science and Higher Education of the Government of St. Petersburg

## References

[1] P. Artymowicz & S.H. Lubow, Astrophys. J. 467, L77 (1996).
[2] P.V. Kaigorodov et al., Astron. Rep. 54, 1078 (2010).
[3] J.D. Larwood & J.C.P. Papaloizou, MNRAS 285, 288 (1997).
[4] V. Springel et al., New Astronomy, 6, 51 (2001).
[5] V. Springel, MNRAS, 364, 1105 (2005).
[6] T. Demidova et al, Astron. Lett. 36, 498 (2010).
[7] V. Grinin et al, Astron. Lett. 36, 808 (2010).
[8] A. Rostopchina et al. Astron. Rep. 51, 55 (2007).