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Hydrodynamical Evolution of Circumbinary Accretion Disks

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Abstract. SPH simulations of circumbinary accretion disks are verified with the help of a grid-based Eulerian code. The phenomenon of pulsed accretion flow through the central gap is confirmed.

Circumbinary disks are known to have gaps cleared of the gas by tidal and resonant forces. Based on SPH simulations, Artymowicz & Lubow (1996, hereafter AL) find that a *pulsed accretion flow* across the gap may occur, proceeding entirely through narrow, high-velocity streams. They also suggest that similar streams may originate in a protoplanetary disk when a newly formed planet grows massive enough to open a gap. If this is indeed the case, gap formation should not inhibit accretion onto planets, and super–Jovian objects like those recently discovered (Marcy & Butler 1996) could easily form. Due to its potential importance, pulsed accretion flow deserves a particularly careful examination.

We report three sets of grid-based Eulerian simulations with binary mass ratios and orbital eccentricities of $q = 3:7$ and $e = 0.1$ (*low-e case*), $q = 1:1.27$ and $e = 0.5$ (*high-e case*), and $q = 1:1000$ and $e = 0$ (*Jupiter case*). In accordance with AL we find that in all cases the model quickly relaxes to a quasi-stationary state, in which streams of gas originating at the inner edge of the disk flow across the gap. The mass flux in the streams varies significantly during one orbital period (Fig. 1a), but when averaged over several periods it has a well defined value, approximately equal to that found in an axisymmetric disk of the same viscosity orbiting a single star.

Also in accordance with AL, we observe that the secondary obtains a larger share of the total mass flux, and that in the high-e case the streams practically disappear at some orbital phases of the binary. In high-viscosity disks accretion rates onto central stars scale in rough proportion to the kinematic viscosity coefficient (assumed constant throughout the disk). However, low-viscosity models fail to obey this relation, suggesting that an additional source of effective viscos-

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ity is active in the disk (Fig. 1b). We associate this viscosity with two-armed spiral shock waves excited by the nonaxisymmetric, time-dependent potential of the binary (Różyczka & Spruit 1993).

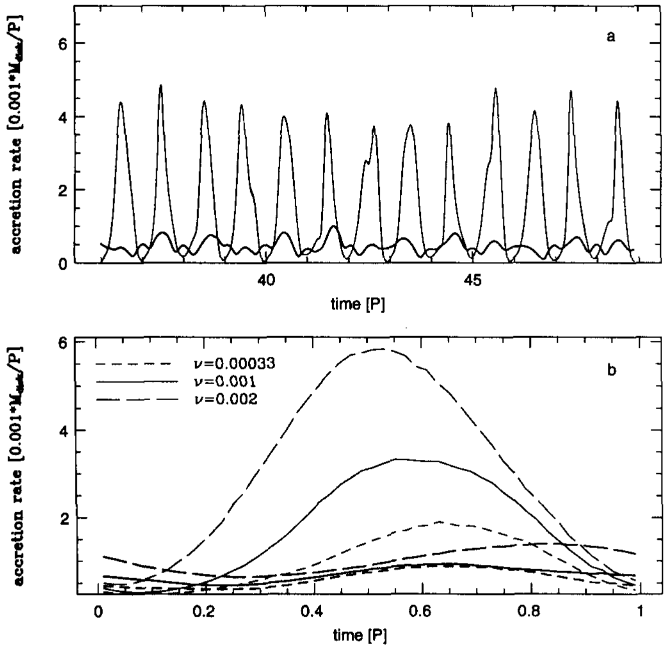

Figure 1. Low-e case. a: Accretion rates onto the primary (heavy) and secondary component (light) during orbits 37 - 49 of the binary. b: Phase–binned accretion rates onto the primary (heavy) and secondary (light) obtained for three values of the viscosity coefficient indicated in the upper left corner (averages from 50 orbits).

In the Jupiter case a one-armed spiral wave is excited, and the flow across the gap onto the secondary occurs in a small region which precedes the secondary along its orbit. The amplitude of mass flux variations seems to be much lower than in either of the two cases described above. High–resolution simulations for the Jupiter case are currently underway.

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