DYNAMICS OF THE EPSILON AURIGAE RING MODEL

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1. INTRODUCTION

It has recently been suggested (Lissauer and Backman, 1984; Eggleton and Pringle, 1985) that the secondary mass within the Epsilon Aurigae disk is not a single object but an embedded binary. Lissauer and Backman pointed out that this idea would help greatly to account for its low ratio of luminosity to mass, while Eggleton and Pringle argued in addition that the system's evolution could be much better understood in terms of such a configuration. They also noted that a central opening in a thin disk, which was proposed by one of us (Wilson, 1971) as a means to produce certain unusual features of the eclipse, can be accounted for quite naturally if the disk has a binary at its center. With such an embedded binary, circular orbits will be impossible for particles inside a critical radius, leading to an effective viscosity which will cause disk material to spiral inward.

2. ANALYSIS

We have now carried out computations in which we follow the motion of ring particles in a restricted four-body problem, similar to the restricted three-body problem of classical celestial mechanics, except that one of the finite-mass bodies is a tight binary with orbital separation much smaller than that of the wide system, as may be the case in Epsilon Aur. In our preliminary work we have found a rather well defined distance from the inner binary, outside of which essentially circular orbits are possible, and inside of which they are not. We also find that the ring remains sensibly planar and aligns with the orbit plane of the inner binary, provided that the orbit planes of the inner and wide binary are only slightly (say 1 degree or so) out of coincidence. This latter point is crucial in accounting dynamically for the slight misalignment needed by Wilson to produce eclipses of the observed depth (otherwise the only preferred plane would be that of the wide binary). We shall publish our specific numerical results, including estimates of the inner binary separation, when we have completed

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experiments with a variety of mass distributions among the three finite bodies.

3. DISCUSSION

The 1971 thin ring model has several major advantages over the only other presently viable model, the Huang (1965) thick disk model. The ring opening accounts naturally for the central brightening observed in the 1983 and 1956 eclipses (light of the F0 supergiant streams through the opening). The ring model allows the distance to be of the order of half a kiloparsec, rather than the 1.2 kiloparsecs required by the Huang model. The measured spectroscopic-astrometric distance is 580±30 parsecs (van de Kamp, 1978). In fact, Wilson (1971) predicted, before van de Kamp's distance measurement had been made, that the distance would turn out to be about 500 pc, although at the time the distance was believed to be 1200 pc. With only small epoch to epoch changes in the ring geometry, the model permits the durations of the flat bottom and whole eclipse to vary in opposite senses (as observed) without changing the radius of the supergiant. Also, small dips which have been observed several times at the beginning and end of the flat section may well be the features calculated by Wilson as the signature of a ring eclipse. Thus the model continues to agree with observations, and if the dynamical difficulties posed by the inclination of the ring plane and by the existence of the ring opening can be ascribed to a central binary, the last major problems for the ring model may have been solved.

4. REFERENCES

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