ON A MECHANISM THAT STRUCTURES GALAXIES

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By considering the interaction of a single stellar orbit with a weak cos 2ϕ potential it is shown that in the central regions of galaxies with slowly rising rotation curves, the elongations of the orbits will align along any potential valley and oscillate about it. This effect is more pronounced for elongated orbits. In such regions any pair of orbits will naturally align under their mutual gravity and so a bar will form. The gravity of this bar will drive a spiral structure in the outer parts of the galaxy where differential rotation is too strong to allow the orbits to be caught by the bar. The spiral structure carries a torque which slowly drains angular momentum from the bar, gradually making its outline more eccentric and slowing its pattern speed. In the outer parts of the bar only the more eccentric orbits align with the potential valley; the rounder ones form a ring or lens about the bar. As the pattern speed slows down, the co-rotation resonance and outer Lindblad resonance, which receive the angular momentun, move outwards. The evolution of the system is eventually slowed down by the weakness of these outer resonances where the material is rather sparse.

DISCUSSION

Miller: In a detailed study of the dynamics of a stellar bar we find that orbits in the bars of numerical experiments form figure-8's (as seen from a frame that rotates with the bar pattern), quite different from the elliptical loops you described. We find no ellipse-like orbits inside the bar region, out of a study of 1500 orbits. The elliptical orbits cannot have been important in earlier stages of the formation of the bar, because there is no way for a self-consistent system to switch over from domination by elliptical orbits to domination by figure-8 orbits. We find the bar to be slowly rotating; elliptical orbits are appropriate to rapidly rotating configurations.

Lynden-Bell: Your bars and my bars are different, although mine secularly slow down and would eventually trap orbits of your type.

W. B. Burton (ed.), The Large-Scale Characteristics of the Galaxy, 157–158.

Bok: The term "bar" is being used to denote all sorts of objects. Can we have some summary about the astrophysical and kinematical properties of observed bars in barred spirals before we refer to bar-like features obtained from numerical calculations?

No response.

Sanders: Taking the Rougoor-Oort rotation curve for the inner region of the Galaxy, the quantity $\Omega - \kappa/2$ increases to high values inside 2 or 3 kpc. Does this mean that particle orbits in the inner Galaxy are "donkeys"; that there is an anti-bar-forming tendency in the inner part of the Galaxy?

Lynden-Bell: Yes, our Galaxy is anti-barring in the middle but may be barring a little further out where the velocity curve rises again.

Contopoulos: I have made some calculations similar to Dr. Lynden-Bell's and would like to give a counterexample. The periodic orbits inside the inner Inner Lindblad Resonance (dashed circle) are elongated along the bar. So at first glance they should enhance the bar, as pointed out by Dr. Lynden-Bell. However, the orbits are more elongated near the resonance than closer to the center, where they are more circular. Thus the orbits are congested near the line PP, perpendicular to the bar. This congestion may overcome the enhancement along the bar and produce a maximum of density perpendicular to the bar. In fact, I found several models where this is the case. Thus one should be careful to take into account all the important effects that contribute to the stellar density. On the other hand, the congestion of gas should be smaller because of pressure effects. Therefore, the response along the bar probably should be larger. This is consistent with the calculations of the gaseous response made by Sanders.