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The building blocks of the spiral arms in galaxies

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Spiral galaxies make up a very large proportion of all the galaxies in the Universe. Morphologically, about two-thirds of spiral galaxies present a bar in their center and are called barred spiral galaxies. The rest of the spiral galaxies have no bar and either they present well defined spiral arms (called "grand design galaxies" which usually have two well defined spiral arms), or they present multi-arm and flocculent spirals which have subtler structural features. We investigate the types of the orbits of the stars that form the building blocks of the spiral arms in the case of the "grand design" galaxies as well as in the case of the barred spiral galaxies (like the Milky Way). In the case of the grand design galaxies with no bar, organized elliptical orbits can create a density wave in a spiral form, according to the density wave theory ([1],[2],[3],[4]). We give such an example of an analytical galactic model and we investigate the dependence of this spiral density wave on the amplitude of the perturbation of the model, the pattern speed and the pitch angle of the spirals.
On the other hand, in the case of spiral galaxies with bar, the density perturbation due to the bar, is so large, in relation with the axisymmetric background that there exist no more organized orbits that can support the spiral arms. For this type of galaxies the dominant theory for the formation of the spiral structure, nowadays, is the "manifold theory" introduced in 2006 ([5],[6]) according to which chaotic orbits with initial conditions along the unstable manifolds of unstable periodic orbits in the vicinity of the corotation, as well as sticky chaotic orbits close to the previous ones can support the spiral structure of the galaxy for long enough times before they go too far. We give such an example of a Milky-Way like barred spiral galaxy and we reconstruct the spiral structure using the chaotic orbits described above. Finally, we investigate the case where the bar and the spirals have different pattern speeds..

References

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