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Transient spiral arms and galaxy rotation curves

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We describe how a simple class of out of equilibrium, rotating and asymmetrical mass distributions evolve under their self-gravity to produce a quasi-planar spiral structure surrounding a virialized core, qualitatively resembling a spiral galaxy. The spiral structure is transient, but can survive tens of dynamical times, and further reproduces qualitatively noted features of spiral galaxies as the predominance of trailing two-armed spirals and large pitch angles. As our models are highly idealized, a detailed comparison with observations is not appropriate, but generic features of the velocity distributions can be identified to be potential observational signatures of such a mechanism. Indeed, the mechanism leads generically to a characteristic transition from predominantly rotational motion, in a region outside the core, to radial ballistic motion in the outermost parts. Such radial motions are excluded in our Galaxy up to 15 kpc, but could be detected at larger scales in the future by GAIA. We explore the apparent motions seen by external observers of the velocity distributions of our toy galaxies, and find that it is difficult to distinguish them from those of a rotating disc with sub-dominant radial motions at levels typically inferred from observations. These simple models illustrate the possibility that the observed apparent motions of spiral galaxies might be explained by non-trivial non-stationary mass and velocity distributions without invoking a dark matter halo or modification of Newtonian gravity. In this scenario the observed phenomenological relation between the centripetal and gravitational acceleration of the visible baryonic mass could have a simple explanation.

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