THE PERSISTENCE OF WARPS

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Hunter and Toomre (1969) have demonstrated that a simple warp of a stellar disk will damp out within one or two galactic rotation periods due to rapid differential recession of stellar orbits. If, however, the galactic gravitational field is more nearly spherically symmetric, the rate of differential recession is decreased and the warp may persist for a longer time. We therefore propose that the observed gaseous warps exist in regions outside of the massive stellar disk; that is, in regions where the gravitational field is essentially spherically symmetric. A necessary condition of this hypothesis is that long-lived warps are present only in a low mass, low random velocity component of the galaxy -- presumably the gas.

We have investigated this hypothesis by numerically integrating the motion of test particles in a model galactic gravitational field (Tubbs and Sanders 1978). The model galaxy consists of two components: a highly flattened disk and a spherical halo. The disk is truncated at some radius, R_d, and the halo extends beyond the disk. The form of the density distribution is chosen to give a flat rotation curve within the disk. A critical parameter in this model is μ, the halo-to-disk mass ratio within R_d. Such a model is entirely consistent with Sancisi's observations of the rotation curve in NGC 5907 (1978) and Van der Kruit's sky-limited photographs of this galaxy (1978).

We examined two sets of initial conditions for our test particles: a primordial warp in which we simply tilt an outer annulus of particles, and a tidal warp, in which the particles in an outer annulus of particles receives a vertical impulse. We allow the particles to move in the given gravitational field, and, after some time, view them edge-on from various azimuthal angles. Below we see the state of a primordial warp after 10^{10} years. This is the distribution of test particles presented in the form of a high-velocity "channel" map (i.e. the column density in a 15 km s^{-1} velocity range around 230 km s^{-1}) smoothed to the resolution of the Westerbork beam. For the warp to persist for 10^{10} years we require that the stellar disk be truncated and that $\mu = 3$. "Primordial" or tidally caused warps beyond a truncated massive stellar disk may persist for 5×10^9 years if $\mu \geq 1.5$.

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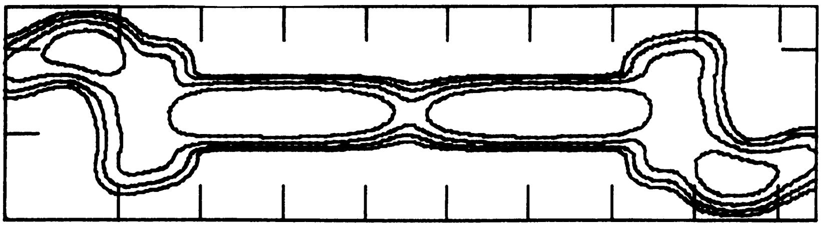

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