CENTRAL NGC 2146 – A BENDING INSTABILITY IN THE DISK OF NEWLY FORMED STARS ?

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As the observations of highly flattened galaxies including the Milky Way and many-body (N-body) simulations show, the central parts of these systems, say, at distances $r < 0.5 - 0.7$ kpc from the center, rotate slowly and their local circular velocities of regular rotation become less than (or comparable to) the residual (random) velocities. In such a thin, practically nonrotating circumnuclear disk, a typical star moves along the bending, perpendicular to the equatorial plane layer under the action of two forces which act in opposite directions: the destabilizing centrifugal force F_c and the restoring gravitational attraction F_g. Obviously, fierce instabilities of the buckling kind developing perpendicular to the plane may not be avoided if $F_c > F_g$. The latter condition is none other than the condition of "fire-hose" electromagnetic instability in collisionless plasmas which is driven by the particle "pressure" anisotropy.[1]

It seems reasonable that this is a natural mechanism for building a snake-shaped radio structure which has recently been observed by Zhao et al. (1996) in the central region of the spiral starburst galaxy NGC 2146 with the Very Large Array at an angular resolution of $2''$ (Griv 1997). N-body simulations of the firehose-type bending instability are presented for this galaxy. A theoretical prediction is confirmed that the instability is driven by excess of plane kinetic energy of random motions of stars, when the ratio of the dispersion of radial velocities of stars ("temperature") in the plane c_r

[1]The firehose-type bending instability of a sufficiently thin stellar disk has been predicted by Toomre (1966) by using the theory based on moment equations. This instability was also discovered independently by Kulsrud et al. (1971) and Mark (1971) with a more accurate kinetic theory. Polyachenko & Shukhman (1979), Fridman & Polyachenko (1984), and Polyachenko (1992) have pointed out that the usual name for this instability of particulate systems – firehose instability – recalls the fact that the unstable motion of a hose when the flow velocity of water inside becomes very high has essentially the same nature.

Y. Sofue (ed.), The Central Regions of the Galaxy and Galaxies, 287-288.

to the velocity dispersion in the perpendicular direction c_z is large enough, $c_r > (0.5 - 0.6)c_z$. In other words, if the thickness of the stellar disk $h \propto c_z$ is small enough.[2]

The extent to which our results on the disk's stability can have a bearing on observable spiral galaxies with a high star formation rate in the central parts is discussed. It is suggested that such the snake-shaped one-side structure perpendicular to the galaxy disk of various scales is likely to be common phenomenon associated with nucleous disks of starburst highly flattened galaxies. For example, the radio emission observations of a number of spiral galaxies with a high star formation rate have reveal an out-of-plane nonaxisymmetric **S**-shaped complex of radio sources at a galaxy's nucleus (Kronberg & Biermann 1981). It seems likely that the origin of these off-plane **S**-shaped complexes may be explained by the bending firehose-type instability as outlined above.

In particular, a tentative model is offered which accounts in a simple and coherent manner for the anomalous phenomenon observed toward the nucleus of our own Galaxy: the $\mathbf{\Omega}$-shaped Galactic Arc emerging from the nuclear disk toward the positive galactic latitude (Sofue & Handa 1984; Sofue 1985; Morris & Yusef-Zadeh 1989).

The work was supported in part by the Israeli Ministry of Immigrant Absorption, the Israeli Ministry of Science, and the Academia Sinica in Taiwan.

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[2]As is known, the latter effect explains why there are no elliptical galaxies with an oblateness exceeding a definite critical value: the largest oblateness is possessed by the galaxies of the Hubble type E7 (Fridman & Polyachenko 1984; Polyachenko 1992).