ON SOME OBSERVATIONAL RESTRICTIONS TO GALACTIC SPIRAL STRUCTURE THEORIES

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1- Introduction

We would like to draw attention to some observational data which should not be neglected, in our opinion, in developing spiral structure theories. Some of these results demonstrate Le Chatelier principle well-known in physics. According to this principle, any physical process is proceeding to cancel its cause. Localization of galactic disks near the marginal curves of various instabilities shown below indicates the important role that these instabilities play in evolutionary processes of disks.

2- Gravitational instabilities

It is not difficult to see from observations that stellar and gas disks of spiral galaxies are self-gravitating ones, i.e. they are near the boundary of the gravitational instability. Fig.1 shows, in the conventional notation, the locations of stellar disks for five galaxies; the dotted line is the marginal line for gravitational instability, obtained by Morozov from numerical calculations. Zasov and Simakov (1988) compare the observed suface density of the gas with the marginal one for IC342 and NGC6946, and again the gaseous disks are very near instability.

Strigachev (1990) studying multi-armed (m≥2) galaxies, showed that rather often visible spiral arms surpassed the region between Lindblad resonances. There are 6 galaxies of this sort among the arbitrary sample of 16 galaxies. The spiral arms of the rest of 10 galaxies are located in the region between resonances "on the limit", that is, on the assumption of the absence of the weak extension of the spirals towards outer regions.

To conclude the discussion on the topic connected with the influence of self-gravitational mechanisms of excitation, we touch upon a possibility of the new bar-mode generation suggested by Polyachenko (1989). The essence of the mechanism consists on the formation of a bar due to Jeans-like instability leading to angular attraction of stars orbits (as a whole) to each other (fig.2). In contrast to the classical bar-mode, this instability may be generated also at smaller velocities of the rotation of galactic central parts. The necessary condition for its excitation is a sufficiently small value of the precession velocity dispersion of stellar orbits.

3- Hydrodynamical conception of spiral structure generation

The detailed observational program for the 6m telescope (Afanasiev et al, 1988, 1990)

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was worked out based on the hydrodynamical conception of the spiral structure generation. A large number of rotation curves have been obtained for spiral galaxies. From a sample of 24 galaxies, VK-galaxies with $\Delta v/v > 10$-15% are more than half. These VK-galaxies have been studied further during the last year, they appear usually near the boundary of hydrodynamical instability.

According to Strigachev (1990), Sa-galaxies are absent from multiple-armed galaxies. Among multi-armed galaxies, Sc-type is found about twice as often as other morphological types. This fact can be simply explained within the framework of the hydrodynamical conception. As Sa-galaxy contains a more massive central part than Sc-galaxy, the mean rotation velocity of Sa-galactic disk is higher. So the number of arms should be less in Sa-galaxies.

4- Influence of viscosity

Fridman and Zasov (1987, 1990) suggested a simple method to check the viscous force influence in gas disks (see also Icke 1979; Simakov 1990). The viscous force in gas disk is $F = \eta\, d/dr\, [1/r\, d/dr\, (r\, v_{o\varphi})]$, where η is the dynamic viscosity. If the profile of the rotation curve is:

$v(r) = \alpha\, r$ for $0<r<R_m$,
$v(r) = \beta$ for $r>R_m$, with α and β constant

then the viscous force is:

$F \approx 0$ for $0<r<R_m$,
$F<0$ for $r>R_m$.

Hence the surface density must be raked up by viscous forces to the $r=R_m$, forming there a hump. As viscous force for fast rotation is more efficient than for slow one, the correlation between the point $r=R_{HI}$ (where is the maximum of surface density) and $r=R_m$ is stronger (fig 3).

5a-Conclusions

1) There are stellar and gas disks near the boundary of the gravitational instability.
2) There are stellar and gas disks near the boundary of the hydrodynamical instability.
3) There are disk's parameters of spiral galaxies wich do not satisfy some conditions of the gravitational instability theory, or the hydrodynamical one.
4) The role of the viscosity for a large-scale structure generation may be very important.

5b- General Conclusion

The universal theory of the galactic spiral structure generation does not exist.
There should be several mechanisms of the galactic spiral arms generation.

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Fig. 1: A diagram C_r/V_c - M_b/M_{disk} for disk galaxies with known velocity dispersion C_r of old stellar disk and circular velocity V_c. The dashed line corresponds to numerical disks models by Morozov. M_b/M_{disk} is mass ratio of spherical to disk components for marginal stability. 1-: NGC936; 2-: NGC1553; 3-: NGC7184; 4-: NGC5170; 5-: Milky Way.

Fig. 2: New bar-mode (Polyachenko 1989). *Solid arrows:* the gravitational torques for the star orbits 1 and 2. *Dotted arrows:* the rotation of the final bar (the angular velocity $\Omega_p = \Omega$, where Ω is the mean velocity of star orbit precession.

Fig. 3: Relation between radius R_{HI} of maximal surface density of HI and maximum radius R_m of the rising part of the rotation curve for galaxies with $V_m > 150$km/s (*left*) and $V_m < 150$ km/s (*right*), from Fridman and Zasov (1987).

Fig. 1

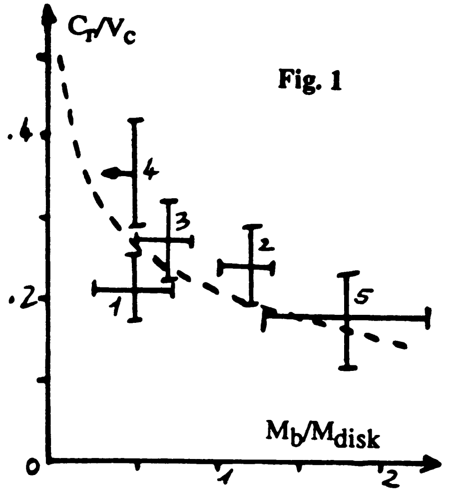


Fig. 2

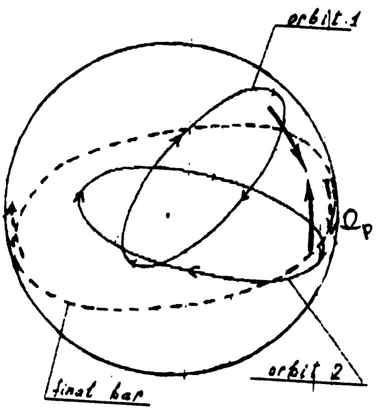
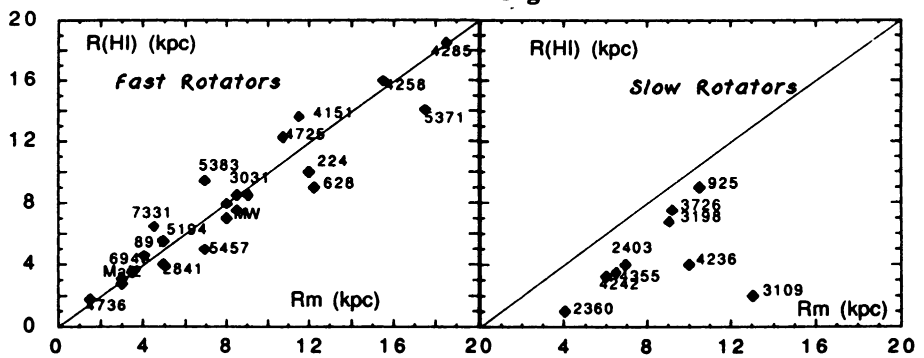


Fig. 3



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