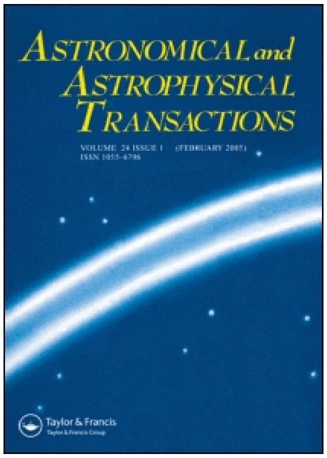

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V. A. Antonov [a]; O. A. Zheleznyak [b]
[a] Institute for Theoretical Astronomy, St. Peterburg, Russia
[b] Uman Pedagogical Institute, Ukraine

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NON-STATIONARY DISKS IN THE CENTERS OF ELLIPTICAL GALAXIES[†]

V. A. ANTONOV[1] and O. A. ZHELEZNYAK[2]

[1] *Institute for Theoretical Astronomy, St. Peterburg, Russia*
[2] *Uman Pedagogical Institute, Ukraine*

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A model for the disk formation in central region of rotating triaxial elliptical galaxies is proposed. The disks form as a result of the matter accretion from the periphery of the rotating galaxy.

KEY WORDS Elliptical galaxies, Gas-dust disks

In recent observations (Demonlin-Ulrich, 1984) non-stationary gas-dust discs have been discovered in some elliptical galaxies. Spectral investigations of these non-stationary discs show that they are expanding and have rather high turbulent velocities. The rotation of these formations is considerably more rapid than the rotation of the stellar component of the parent galaxy. The disks can be different by a tilt with respect to the principal planes of the galaxy; the orientations range from disks lying in the equatorial plane to those oriented almost perpendicularly to it. In some cases the non-stationary disks rotate backwards with respect to the stellar component, i.e. there are mutual counterflows.

We explain these dynamical properties by the acceleration of the gas-dust matter in a triaxial rotating stellar system. It is assumed in our model that the gas-dust matter had been displaced from central regions of the galaxy as a result of active processes and later, after the activity had died out, the matter settled in the galactic gravitational field. For a gas-dust particles one can write the equations of motion in the coordinate system that rotates with the angular velocity Ω together with the galaxy:

$$\frac{d\mathbf{u}}{dt} = \frac{\partial \Phi}{\partial \mathbf{r}} - \boldsymbol{\Omega} \times (\boldsymbol{\Omega} \times \mathbf{r}) - 2(\boldsymbol{\Omega} \times \dot{\mathbf{r}}). \tag{1}$$

The gravitational potential Φ is chosen in a form typical of a triaxial ellipsoid. Initial conditions represent matter in rest at the galactic periphery with respect to this coordinate system. Thus, equation (1) is solved analytically by successive approximations. It appears that the intersections of trajectories generate collisions of two kinds depending on the system parameters. The collisions happen either on

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the equatorial plane, or at the meridional one, but in general not on the principal planes. When the collisions are localized on the equatorial plane, the velocity field is

$$\begin{aligned} v_R &= \frac{4\pi G\rho C^2 R t_0}{5\beta r_0}[(c^1 - b^1)\cos^2\theta + (c^1 - a^1)\sin^2\theta], \\ v_\theta &= \frac{C^2 R}{\beta}\left[\frac{4\pi G\rho t_0}{5r_0}(b^1 - a^1)\sin\theta\cos\theta + \Omega\right], \end{aligned} \qquad (2)$$

where

$$\beta = \left(\frac{4\pi G\rho t_0}{5r_0}\right)(a^1 - c^1)(b^1 - c^1) + \Omega^2,$$

$t_0 = \frac{\pi}{2C}$ is the characteristic time of the accretion onto the center in the absence of the rotation and the triaxility, and a^1, b^1 and c^1 are small deviations of the galaxy semi-axes from equal values corresponding to a sphere.

The surface density is given by

$$\begin{aligned} \sigma(x,\, y) = 2\sigma_0 r_0\left\{\left(\frac{\Delta r_0}{C}\right)^2\right. &- \left[\frac{4\pi^2\rho}{5r_0}(b^1 - c^1)t_0 x + \Omega y\right]^2 \\ &- \left.\left[\frac{4\pi^2\rho}{5r}(a^1 - c^1)t_0 y + \Omega x\right]^2\right\}^{-1/2}, \end{aligned} \qquad (3)$$

where

$$\Delta = \left[-C\tau + \frac{4\pi G\rho(a^1 - c^1)t_0}{5Cr_0}\right]\left[-C\tau + \frac{4\pi G\rho(b^1 - c^1)t_0}{5Cr_0}\right] + \frac{\Omega^2}{C^2},$$

$$\tau = t - t_0.$$

Correspondingly, for the collisions on the meridional plane, the velocity field is

$$v_R = -\frac{C^2\sin 4\varphi}{4\Omega}R, \quad v_\varphi = \frac{C^2\sin 2\varphi}{2\Omega}R, \qquad (4)$$

and the density is given by

$$\sigma(R,\, z) = \frac{\sigma_0|\sin 2\varphi|}{\Omega|\tau|}\left[1 - \left(\frac{CR\sin 2\varphi}{2\Omega r_0}\right)^2 - \left(\frac{z}{C\tau r_0}\right)^2\right]^{-1/2} \qquad (5)$$

As the formulae (3) and (5) show, non-stationary disks have an elliptical form and their density grows to the periphery. Formulae (2) and (4) indicate that elliptical non-stationary disks rotate more rapidly than the stellar component of the galaxy ($c^2/\Omega \gg 1$). Local matter counterflows are possible under certain conditions. The velocity field shows both possibilities: the density increasing (div $v < 0$) in some cases and decreasing (div $v > 0$) in other cases. However, the gas expansion correlates with its heating, therefore gas has a better chance to be observed.

Reference

Demoulin-Ulrich, M. H. (1984) *Ap. J.* **285**, 527.

DISCUSSION

Fridman: Do you take into account inelastic collisions if you use the momentum conservation equations only?
Antonov: We have the extremal case with only inelastic collisions. Thermal energy just goes away with radiation. The colliding layers become an averaged momentum in any little region. This dynamical behavior is one-valued.
Antonov: One more comment. The dust (or very cold gas) envelope falling inside changes sharply its topology in a critical state. Its skirts both collide each other and coalesce. We investigate the only case when the result of the coalescence gets rapidly cold and, nearly immediately, the cold medium dynamics are restored to their rights. Thus we obtain an ordinary shock.