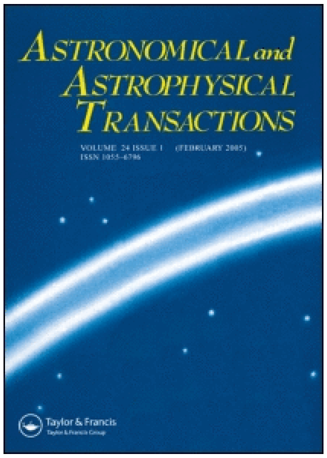

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# On the origin of galaxy chains

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## SHORT NOTE

# ON THE ORIGIN OF GALAXY CHAINS

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We propose the hypothesis that galaxy chains are a result of disintegration of a rotating self-gravitating toroidal body.

KEY WORDS Chains, galaxies.

A chain of galaxies typically contain several galaxies and have diverse spatial configurations. According to photometry, the mean color of these galaxies is $\langle B-V\rangle \approx 0.4$ and $\langle U-B\rangle \approx -0.4$, which is very close to that of irregular galaxies (Metlov, 1979). The average size of a chain ($l$) is approximately 30 kpc. Observations imply a physical connection between the galaxies forming a chain and the average velocity ($v$) difference between the components of a chain is 250 km/s ($\Delta v \approx 250$ km/s). This can be explained by rotation around a common center (Vorontsov–Velyaminov, 1979). In some cases, a galaxy belonging to a chain exhibits a strong deviation in velocity from other chain members.

In this paper, the hypothesis of a common origin of the galaxies forming a chain is proposed. The main idea is that the chains are a result of the disintegration of a rotating self-gravitating toroidal body. The gravitational instability leads to the concentration of the matter on one side of the toroidal body resulting in an asymmetric configuration which looks like a knot-shaped biscuit. Further matter compression gives origin to new galaxies and a galaxy chain.

The mass distribution asymmetry affects the redistribution of the angular momentum and one of the galaxies can receive a much larger velocity with respect to the chain centre than other galaxies.

Using the conservation of energy, we can demonstrate that this is possible. The total mechanical energy of a self-graviting toroidal body is equal to the total energy of the chain:

$$\tfrac{1}{2}I_r\omega_r^2 + \Pi_r \approx T_c + \Pi_c, \qquad (1)$$

where

$I_r = M_r(R^2 + \tfrac{3}{4}a^2)$ is the moment of inertia of the toroidal body,

$\Pi_r \approx -\dfrac{GM_r^2}{2\pi R}\ln\dfrac{8R}{a}$ is the gravitational energy of thin toroidal body,

$M_r$ is the mass of the toroidal body,

$\omega_r$ is its angular velocity,

$R$ and $a$ are the larger and smaller torus radii, respectively, and

$T_c$ and $\Pi_c$ are the kinetic and potential energy of the chain.

The potential energy of the chain is given by

$$\Pi_c = -\frac{G}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\frac{m_i m_j}{r_{ij}} \quad (i \neq j),$$

where $m_i$ and $m_j$ are the galactic masses and $r_{ij}$ is the distance between the galaxies. Consider four galaxies of the same mass $m$ which have been formed from the "knot-shaped biscuit" located at distance $R$ from the center of mass of other galaxies in the torus. The latter are separated by distance $\lambda$ corresponding to the critical wave-length for gravitational instability. Eq. (1) then takes the form

$$M_r(R^2 + \tfrac{3}{4}a^2)\omega_r^2 - \frac{GM_r^2}{\pi R}\ln\frac{8R}{a} \approx 3m(\Delta v)^2 + m v_4^2 - \frac{Gm^2}{R}\left(1 + \frac{5R}{2\lambda} + \frac{2R^2}{R^2 - \lambda^2}\right).$$

Taking into account that $\omega_r \approx \Delta v/R$, we find

$$\gamma = \frac{v_4}{\Delta v} \approx \left[\frac{M_r}{m}\left(1 + \frac{3}{4}\frac{a^2}{R^2}\right) + \frac{Gm}{(\Delta v)^2 R}\left(1 + \frac{5R}{2\lambda} + \frac{2R^2}{R^2 - \lambda^2}\right) - 3 + \frac{GM_r^2}{\pi R m(\Delta v)^2}\ln\frac{a}{8R}\right]^{1/2}. \tag{2}$$

Thus, $\gamma \approx (2 + 3)$ for the following typical values of relevant parameters: $\Delta v \approx 250$ km/s, $m \approx 10^{11} M_\odot$, $R \approx l/2 \approx 15$ kpc, $a \approx \lambda \approx 3$ kpc and $M_r = 4m$.

From the physical point of view, effect discussed above is due to a partial transformation of torodial bodies the gravitational energy of the toroidal body into the kinetic energy of the galaxies.

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