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ON THE POTENTIAL OF A ROTATING BAR OF REGULAR GALAXIES

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ABSTRACT

This paper deals with steady-state gravitational potentials of nonaxisymmetric three dimensional systems which rotate with a constant angular velocity. For these systems a class of potentials with local integrals has been found.

Key Words : potential, galaxies, integral

Is there a general potential which can be used in constructing self-consistent models of the rotating regular galaxies? It is well known that the potential of the galaxies is nonaxisymmetric. Therefore, it would be of interest to discover new nonaxisymmetric potentials. In our previous papers(Antonov & Shamshiev, 1992, 1993, Shamshiev, 1995) some class of the potentials having local integrals for the systems with two and three degrees of freedom have been constructed. The potentials obtained can be used in modeling rotating regular galaxies, particular of the SB-galaxies.

Let us consider a steady-state, nonaxisymmetric system rotating with a constant angular velocity Ω. Let the unit under the certain initial conditions a velocity field (u, v, w), in the form

$$\begin{aligned} u &= u_0 \pm \alpha\sqrt{S+2h} + \Omega \cdot y \\ v &= v_0 \pm \beta\sqrt{S+2h} - \Omega \cdot x \\ w &= w_0 \pm \gamma\sqrt{S+2h} \end{aligned} \tag{1}$$

where $S, u_o, v_o, w_o, \alpha, \beta, \gamma$ are functions of coordinates, h is an arbitrary constant of the energy. The local integral can be expressed in the easiest way by excluding h. The aim of this paper is to construct a class of potentials having this velocity field, if it exists. We assume that for the functions α, β, γ the equality

$$\alpha^2 + \beta^2 + \gamma^2 = 1\,. \tag{2}$$

is true.

The existence of the velocity field is checked by usual way, the expression $(u - \Omega \cdot y) \cdot dx + (v + \Omega \cdot x) \cdot dy + w \cdot dz$ for any particular trajectory must be a total differential. The condition is true for univalent part of (1) and for the parts containing the square root. In the first case we obtain a condition which leads to $(u_o, v_o, w_o) = \nabla F(x, y, z)$, where F some function. In the second case the following condition is obtained

$$(S+2h)[\frac{\partial \alpha}{\partial y} - \frac{\partial \beta}{\partial x}] + \frac{\alpha}{2}\frac{\partial S}{\partial y} - \frac{\beta}{2}\frac{\partial S}{\partial x} = 0 \tag{3}$$

Since (3) must be true for any h it is necessary to have

$$\frac{\partial \alpha}{\partial y} - \frac{\partial \beta}{\partial x} = 0, \ldots$$

that is, α, β, γ are gradients of some function $L(x, y, z)$.

The remaining part of (3)

$$\frac{\partial L}{\partial x}\frac{\partial S}{\partial y} - \frac{\partial L}{\partial y}\frac{\partial S}{\partial x}, \ldots$$

which is a jacobian, shows that S must be functionally depend on L, that is, $S = U_0(L)$,

So,

$$\begin{aligned} u &= \frac{\partial F}{\partial x} + \Omega y \pm \frac{\partial L}{\partial x}\sqrt{U_0(L)+2h} \\ v &= \frac{\partial F}{\partial y} - \Omega x \pm \frac{\partial L}{\partial y}\sqrt{U_0(L)+2h} \\ w &= \frac{\partial F}{\partial z} \pm \frac{\partial L}{\partial z}\sqrt{U_0(L)+2h} \end{aligned} \tag{4}$$

Using the known Jacobi integral with (4), we have

$$\begin{aligned} 2(U+h) &= (\nabla F)^2 \pm 2\Omega[y\frac{\partial F}{\partial x} - x\frac{\partial F}{\partial y}] \\ &\cdot 2[\nabla F \cdot \nabla L + \Omega(y\frac{\partial L}{\partial x} - x\frac{\partial L}{\partial y})] \\ &\cdot [U_0(L) + 2h](\nabla L)^2, \end{aligned} \tag{5}$$

from where automatically

$$\nabla F \cdot \nabla L + \Omega[y\frac{\partial L}{\partial x} - x\frac{\partial L}{\partial y}] = 0. \tag{6}$$

The function L according to the condition must satisfy the condtion

$$(\nabla L)^2 = 1. \tag{7}$$

Taking into account (6) and (7) from (5), we construct the general form of the potential

$$U = \frac{1}{2}[(\nabla F)^2 + U_0(L)] + \Omega[y\frac{\partial F}{\partial x} - x\frac{\partial F}{\partial y}].$$

The potential can be used in the investigation of rotating stellar systems close to spherical symmetry and SB-galaxies.

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REFERENCES

Antonov V.A., Shamshiev F.T. (1992), AJ, 69, 971

Antonov V.A., Shamshiev F.T. (1993), Celestial Mechanics and Dynamical Astronomy, 56, 451

Schamshiev, F. T. (1995), Astronomical and Astrophysical Transections, 7, 269