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Original article

Rotation of a spiral galaxy without dark matter

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Abstract. The star emits electromagnetic waves intensely, so its motion must be different from that of the planet. Centripetal acceleration during star rotation around the galactic center and the resulted radiation reaction friction creates a valid alternative to the dark matter concept.



Keywords: radiation friction, dark matter, spiral galaxy.

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ФИЗИКА

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Научная статья

Вращение спиральной галактики без темной материи

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Аннотация. Звезда интенсивно излучает электромагнитные волны, поэтому ее движение должно отличаться от движения планеты. Центростремительное ускорение при вращении звезды вокруг галактического центра и возникающее при этом радиационное торможение рассматриваются как альтернатива концепции темной материи.



Ключевые слова: радиационное трение, темная материя, спиральная галактика.

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Charged particles in their individual or collective motion are known to generate plasma radiation. Radiation is the main cause of plasma energy loss. Accelerated motion of charged particles in an external electric or magnetic field underlies the mechanisms of radiation, based on the individual properties of charged plasma particles. The absorption of radiation inside the plasma leads to the effect of blocking radiation. This effect is manifested in the fact that the radiation is not coming from the entire volume of the plasma, but only from its outer layer.

The system emitting electromagnetic waves is not closed. Such a system is dissipative and the laws of conservation of energy and momentum are not applicable. When charged plasma particles move, an electromagnetic field arises, which slows down these particles. At the same time, radiation friction arises due to the emission of electromagnetic waves by moving particles. Considering radiation as a continuous process allows us to interpret it as the result of the action of some force, similar to the force of friction. To find a rigorous solution to such a problem, it is necessary to consider a dynamic system of charged particles and an electromagnetic field described by a complex system of nonlinear differential equations.

The quasi-neutral star plasma consists of electrons and positively charged ions of various types. In addition to its own plasma radiation, the accelerated motion of the star itself should produce some extra radiation. We assume that this radiation originates in all structural layers of the star, but eventually it is emitted into outer space mainly from its atmosphere. Thus, with the accelerated motion of the star, the force of radiation friction should arise. As in classical electrodynamics, we assume that the friction force is proportional to the derivative of acceleration with respect to time (Abraham-Lorentz radiation reaction force [1]): $F = m\tau(da/dt)$, where m and a are the mass and acceleration of the star, τ is the time constant. The rotation of a star around the galactic center, taking into account this force, is described by the equation

$$m \frac{v^2}{r} = G \frac{Mm}{r^2} - m\tau \frac{d}{dt} \left(\frac{v^2}{r} \right), \tag{1}$$

where v is the velocity of the star, r is the distance from the center of the galaxy to the star, G is the gravitational constant, M is the mass of matter inside a conventional sphere with radius r around which the rotation occurs. The solution of the Cauchy problem for equation (1) has the form

$$v^2 = \varphi + (v_0^2 - \varphi) \exp(-t/\tau), \tag{2}$$

$$\varphi = G \frac{M}{r},$$

where v_0 is the initial star velocity. For old star in the galaxy bulge, we can take $t \rightarrow \infty$. In this case, from (2) we obtain

$$v^2 = \varphi = \frac{4}{3} \pi G \rho r^2, \tag{3}$$

where ρ is the average density of matter in the galaxy. As it should be, a linear dependence follows from (3): $v \propto r$. For young star on the periphery or in the spiral arms of the galaxy, the situation is already different. For a young star $\exp(-t/\tau) \approx 1 - t/\tau$, therefore we find

$$v^2 = \varphi + (v_0^2 - \varphi)(1 - t/\tau). \tag{4}$$

If $t \ll \tau$ then $v \propto v_0 = \text{const}$. For such star, the rotation velocity is approximately constant and corresponds to the initial velocity at the time of their formation.

Thus, the rotation pattern of a star in the galaxy depends on the relationship between v_0 and φ as well as the τ value. It is known that stars were not born in the galaxy simultaneously and, therefore, they were included in the circular motion also not simultaneously, but as they appeared. The motion of the young stars ($t < \tau$) is apparently unsteady. Perhaps that's why the galaxy's rotation curve looks so unusual [2]. The present theory is consistent with Tully–Fisher relation, which determines the dependence of intrinsic luminosity of a spiral galaxy and its asymptotic rotation velocity [3]. The faster the galaxy spins, the stronger the radiation friction and the brighter it glows.

This note is for discussion. All of the above exclude the dark matter paradigm. The author shares the doubts that have been increasingly expressed recently regarding the existence of dark matter and the incompatibility of this concept with a number of observed phenomena.

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