A POSSIBLE SERVOMECHANISM FOR MATTER DISTRIBUTION YIELDING FLAT ROTATION CURVES IN SPIRAL GALAXIES

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Abstract. A dynamic model of gravitational interaction was proposed earlier which results in a velocity-dependent drag. This drag can quantitatively explain the cosmological red shift in a stationary universe, the secular acceleration of Phobos, the secular retardation of the Earth's rotation without any problem of the controversial close approach of the Moon and the extra red shift at the solar limb. In the present paper it has been shown that such a velocity dependent inertial induction can act as a servomechanism for distributing matter in rotating spiral galaxies in such a way that flat rotation curves are obtained. A truncated thin disc model has been assumed, but the results are strongly in favour of the proposition.

1. Introduction

It has been now firmly established that almost all spiral galaxies have flat rotation characteristics. The stars in such galaxies have almost circular orbits with speeds almost constant not only for the visible disks but also beyond. The conspicuous absence of the Keplerian fall off has been explained by the theory that a large proportion of galaxy's matter is in dark form. At the same time a number of researchers have pointed out that a servomechanism to distribute the matter in the way required to yield flat rotation curve must be present. Otherwise such a peculiar situation would not have been observed in almost all spiral galaxies. Till now such a servomechanism has not been reported. This paper presents a possible servomechanism which can explain the phenomenon.

2. Dynamic Model of Gravitation and Velocity-Dependent Inertial Induction

A dynamic model of gravitational interaction has been proposed (Ghosh, 1984; and subsequently modified in 1986a) based on the concept of inertial induction and extended Mach’s principle. Application of this model to local interaction has successfully explained the observed large secular acceleration of Phobos (cf. Ghosh, 1986a). It also leads to a modification of the purely tidal friction theory of the secular retardation of the Earth’s spin and the difficulty of the Moon’s close approach is completely resolved (op. cit.). The model also explains the unexplained extra red shift at the limb of the solar disk (Ghosh, 1986b). When the dynamic inertial induction of an object with the rest of the matter in the Universe is considered it not only results in the exact equivalence of inertial and gravitational masses but also quantitatively yields the cosmological red shift without bringing in the concept of cosmological expansion (cf. Ghosh, 1984).

According to the proposed model the force arising out of inertial induction between

two masses $M$ and $m$ can be expressed as

$$F = -\frac{GMm}{r^2} \dot{u}_r - \frac{GMm}{c^2 r^2} v^2 \dot{u}_r f(\theta) - \frac{GMm}{c^2 r} a\dot{u}_r f(\phi),$$

(1)

where $G$ is the coefficient of gravitation*, $c$ is the velocity of light, $r (= \dot{u}_r, r)$, and $a (= \dot{u}_a, a)$ are the position, velocity, and acceleration of $m$ with respect to $M$, and $F$ is the force on $m$. $f(\theta)$ and $f(\phi)$ represent the inclination effects where $\cos \theta = \dot{u}_r \dot{u}_e$ and $\cos \phi = \dot{u}_r \dot{u}_\phi, \dot{u}_r, \dot{u}_e,$ and $\dot{u}_a$ being the unit vectors. As in the previous papers in this paper the following functions will be assumed:

$$f(\theta) = \cos \theta |\cos \theta|, \quad f(\phi) = \cos \phi |\cos \phi|. \quad (2)$$

The variation of $G$ in case of local interaction problems can be ignored and the local value ($= 6.67 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$) can be used.

3. Equilibrium Mass Distribution in Spiral Galaxies for Velocity-Dependent Inertial Induction

In this paper the spiral galaxies will be assumed to be axisymmetric thin disks truncated at a suitable radius within which most of the galactic matter is contained. This obviously makes the situation idealistic; but the main objective of the paper is only to indicate the feasibility of inertial induction to provide the necessary servomechanism.

As the first and the second terms of the right-hand side of Equation (1) falls of as $r^2$ the main contribution will come from the interaction with the local matter present whereas the contribution of the third term represents the contribution of all the matters in the Universe. In the conventional Newtonian approach the contribution of the first term (the usual gravitational pull towards the centre) and that from the third term (the centrifugal force) are made to neutralize so that an equilibrium is achieved. However, the solution is not unique. When the velocity drag (the contribution of the second term) is considered another relationship between the mass distribution and the velocity profile is obtained so that the total tangential force on a mass particle is also zero. If the resultant effect is a pull the body will be pushed out till the pull is zero. Similarly if it is a drag, the body will spiral inwards till it reaches the equilibrium; and a stable equilibrium is achieved. When both the radial and transverse equilibrium conditions are considered unique solutions for both the mass distribution and velocity profile are obtained.

Figures 1(a) and 1(b) show the interaction configuration of a point mass $S$ with an elemental mass inside and outside the orbit of $S$, respectively. The resultant of the velocity-dependent interaction with all the mass inside the orbit of $S$ is represented by a pull $P$ and that for the mass outside the orbit by a drag $D$ as indicated. When the radius

* In this model $G$ is not a constant but depends on the distance between the interacting objects (Ghosh, 1984, 1986a). However, this variation becomes appreciable only when the distance involved is extremely large [$G = G_0 \exp(-4 \times 10^{-27} r), r$ in meters].