Sen, Hari K. The magnetic versus the gravitational field in a homogeneous, incompressible, pulsating sphere of infinite conductivity.

In the present paper, we have considered the meridional oscillations of Ferraro's model¹ of a homogeneous, incompressible spherical star of infinite conductivity in a central, monopole magnetic field, taking into account gravitational forces.² This has led us to a modification of one of the boundary conditions used by Schwarzschild,³ Ferraro and Memory,¹ for the purely magnetic oscillations, viz., that the pressure variation at the undisturbed surface of the star will not vanish but will be equal to the amount of matter supported after the oscillatory distortion. This pressure variation is of the same order as the radial amplitude of the oscillation and was correctly obtained by Miss Gjellestad⁴ in a paper in which she considered the gravitational oscillations of the Schwarzschild model.

To estimate the comparative roles of the magnetic and the gravitational fields, we have considered, in particular, two limiting cases, viz., of small and large magnetic fields. For small fields we have used a perturbation method in which the non-dimensional constant $S^2 = H_s^2/4\pi\rho\lambda^2a^2$ appears as a parameter; a is the radial distance from the center of an internal point in the star, H_s is the surface value of the permanent magnetic field, and $2\pi/\lambda$ is the periodic time of the harmonic vibrations of the star. For Babcock's star⁵ (HD 125248), $S^2 \simeq 10^{-5}$. To the first order in S^2 we find that oscillations with the gravitational period only are possible and that it is necessary to postulate the existence of surface currents.

For very large magnetic fields ($S^2 \rightarrow \infty$) we find imaginary values for λ , indicating either a building up or damping of the oscillation. Physically, the action of the magnetic field would be to damp rather than build up oscillations, and therefore we conclude that in our idealized case of infinite magnetic field the sphere has no (finite) period of oscillation.

Ferraro's series solutions are poorly convergent for intermediate and large values of the variable. We have therefore used asymptotic series expansions of the solutions for intermediate magnetic fields and find again that no oscillations can exist except gravitational ones with surface currents.

We conclude that no meridional oscillations are possible for the Ferraro model of a homogeneous, incompressible, spherical star of infinite conductivity in a central, monopole magnetic field, except the gravitational ones with surface cur-

rents. Miss Gjellestad⁴ reached a similar conclusion for Schwarzschild's model. The result seems to be independent of the model and may very well be true for any initial distribution of density and magnetic field. Further, it is hard to believe that non-meridional oscillations would occur in the absence of meridional ones.

An investigation will be worth while on whether the negative result obtained in this paper is due to the assumption of infinite conductivity that inhibits any motion across the lines of magnetic force. Treatment of a reasonably simple model of finite conductivity and derivation of the asymptotic behavior of the model when the conductivity increases without limit will provide a most useful check.

1. Ferraro and Memory, *M. N.* **112**, 361, 1952.

2. Cf. Cowling, *M. N.* **112**, 527, 1952.

3. *Ann. Astroph.* **12**, 148, 1949.

4. *Ann. Astroph.* **15**, 276, 1952.

5. *Ap. J.* **114**, 1, 1951.

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Shapley, Harlow. Note on the extragalactic distance scale.

Once we have granted that the concentrated star clusters in the Magellanic Clouds are globular clusters comparable with those of the galactic system, we can use their integrated apparent magnitudes, in comparison with the integrated absolute magnitudes of our own globular clusters, to find the distances without using variable stars. This operation has been carried out and published in *Harvard Reprint* No. 372, 1953, where it is shown, however, that the considerable spread in the total magnitudes of globular clusters, the difficulty of measuring diffuse images satisfactorily, and the probably unequally incomplete census of clusters in the two systems, lead only to provisional results. A correction factor of approximately 2.0 was obtained.

A more dependable evaluation of the distances, and of the zero point of the period-luminosity relation for classical Cepheids can be obtained by a method employed in my first survey of the distances of globular clusters, namely, by using the apparent luminosities of the brighter non-variable stars in the clusters. The absolute magnitudes of the stars of top luminosity were first determined by comparison with the variables in those systems that have cluster-type variable stars. The reduction factors have been tabulated for the twelve classes of globular clusters.¹ The bright stars can be used when cluster-type variables are not available. A further advantage of