Principal Features of Metallic Models in Gravitational Field

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Commentary

Received: 24-Sep-2024, Manuscript No. JPAP-24-148682; **Editor assigned:** 26-Sep-2024, PreQC No. JPAP-24-148682 (PQ); **Reviewed:** 10-Oct-2024, QC No. JPAP-24-148682; **Revised:** 17-Oct-2024, Manuscript No. JPAP-24-148682 (R); **Published:** 24-Oct-2024, DOI: 10.4172/2320-2459.12.03.003.

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Citation: Shegelski MRA. Principal Features of Metallic Models in Gravitational Field. Res Rev J Pure Appl Phys. 2024;12:003.

ABOUT THE STUDY

A simple model of a metal in a gravitational field has been reported [1]. The principal features of the model are:

- It reveals the most important physical processes which create the gravitationally induced electric field.
- It determines the direction of the electric field.
- It allows for a manageable calculation of the order of magnitude of the induced field.

Also significant is that the model contains an ample quantity of high quality pedagogical content, suitable for the graduate and strong upper year undergraduate students. In constructing the model, it is necessary that the model contains enough structure in order that the principal problem may be studied and solved, but to also ensure that the model is simple enough that it does not introduce complications which obscure the study. These factors require three components of the model, which are as follows. The nuclei are treated as point particles. The bound electrons around the nuclei are modelled by having these electrons confined inside an impenetrable shell of radius $2a_0$, where a_0 is the Bohr radius. The radius of the shell is calculated in the study. The conduction electrons are treated as a low temperature fermi gas. The fermi gas electrons are held up against gravity by a pressure gradient due to the density of electrons decreasing with height. Due to the dependence of the density of conduction electrons on height, the gravitational compression of the ions must be taken into account as well, as these densities can give a charge density dependent on height. The resultant charge density is too small to contribute to the gravity induced electric field to the leading order calculated in the paper. The nuclei are held up by a combination of two forces. First, gravity causes the nucleus to “sink” a small distance, α below the centre of the shell. This location of the nucleus must be taken into account when calculating the electron bound state. The bound electron also “sinks”, but not as much as the nucleus. The bound electron therefore exerts an upward electric force on the nucleus. The difference in the positions of the nucleus and the expectation in the value of the electron’s position results in an electric dipole moment. At each nucleus, the electric field due to all other dipole moments provides an additional electric force acting to participate in holding the nucleus up against gravity. This simple model requires a highly nontrivial calculation, which results in a net electric field of approximately Mg/e, where M is the mass of the nucleus, g is the Acceleration due to gravity and e is the electronic charge. The gravity induced electric field is of order Mg/e because of the electric dipole moments and Mg/e is the magnitude of the electric field needed at each nucleus in order that the nucleus be held up against gravity and thus also is the value throughout most of the metal. The electric field at the nucleus must be upward to cancel gravity. The wave function for the bound electron is calculated by perturbation theory. The conduction electron states are also calculated by perturbation theory, for pedagogical value and give the same result as obtained using airy functions. The small quantities used for these perturbation calculations are α, the distance from the centre of the shell to the equilibrium position of the nucleus and the perturbation energy of the bound electron due to gravity as well as the electric field in the metal. The model's results are in agreement with experimental results and other theoretical studies [1]. This upward electric field has interesting implications, including relevance to the quantum hall effect.

REFERNCES

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