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Nucleus -Acoustic Waves In Degenerate ONe And CO White Dwarf Cores And Nearly Degenerate Envelopes

We present a theoretic investigation to analyze the low-frequency nucleus-acoustic waves excitable in the completely degenerate (CD) cores of ONe (oxygen-neon) and CO (carbon-oxygen) white dwarfs and their nearly degenerate (ND) envelopes. We use a quantum hydrodynamic formalism to model the complex system dynamics comprising of the electronic species, light nuclear species (LNS), and heavy nuclear species (HNS). The inner concentric layer-wise electronic pressures are judiciously modelled. The equation of state (EoS) for the electrons takes into account contribution due to the electronic pressure (degenerate Fermi pressure for the CD core and the ND pressure for the surrounding transition ambience around the core), pressure due to the interaction of the electrons with other electrons and surrounding nuclei, exchange interaction [1], and correlation interaction [1], explicitly. The constitutive LNS and HNS are governed classically by an appropriate EoS taking into account their thermal pressures. The electronic energy distribution, governed by the Fermi-Dirac thermostistical distribution law, involves both the thermodynamical temperature and chemical potential. It emphasizes on the transition state between the thermodynamical temperature (classical) and the Fermi temperature (quantum) for the borderline regions of intermediate degeneracy [2] for the first time. The model closure is obtained with the help of the gravito-electrostatic Poisson formalism. A normal Fourier-centric spherical mode analysis procedurally yields a generalized linear dispersion relation (sextic in degree). A numerical illustrative platform is employed to highlight the nucleus-acoustic wave propagatory and dispersive features. It is demonstrated that the nucleus-acoustic wave in ONe (CO) white dwarfs exhibits sensible growth features in the transcritical (supercritical) wave space. Its temperature-sensitivity is more (less) prominent in ONe (CO) white dwarfs, and so forth. A full nucleus-acoustic wave dispersion portrayal is illustratively presented and interpreted. The astronomical circumstances sensible of presented study are finally outlined.

References:

- [1] C. Li, Y. Zhan, B. Zhou, J. Zhang, S. Chen, "Electron exchange-correlation effects on dispersion properties of electrostatic waves in degenerate quantum plasmas", Chinese Journal of Physics, vol. 72, p 375-385 (2021). DOI: <https://doi.org/10.1016/j.cjph.2021.05.014>
- [2] Q. Haque, "Drift and ion acoustic waves in an inhomogeneous electron-positron-ion plasma with temperature degeneracy and exchange-correlation effects", Results in Physics, vol. 18, 103287, (2020). DOI: <https://doi.org/10.1016/j.rinp.2020.103287>

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