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Stellar Remnants in the Presence of a Light Scalar

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We study how a Yukawa coupling of the Standard Model fermion to a light scalar affects the stellar structure of cold stellar remnants such as neutron stars. For a broad scalar mass range, the equation-of-state and stellar structure depends only the effective coupling $g_{\rm eff} = g_f m_f/m_\phi$, where g_f is the Yukawa coupling, m_f the fermion mass and m_ϕ the scalar mass. If the effective coupling $g_{\rm eff}$ is larger than O(1), the Yukawa coupled matter exhibits various anomalous behaviors including hydrodynamic instability, negative pressure, distinct phases (soft and hard) of matter with sharp phase boundaries between them and with vacuum. These anomalies can lead to stars exhibiting an unusual mass-radius relation compared to that predicted by Oppenheimer-Volkoff model. To the extent that these anomalies have not and/or will not be observed limits the size of the new Yukawa coupling.

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