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# Is the Central Compact Object in HESS J1731-347 a Hybrid Star ?

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The recent identification of the compact object in HESS J1731-347, with a remarkably low mass of  $M \sim 0.77$  solar mass and radius  $R \sim 10.4$  km, challenges the conventional understanding of dense matter. Such a light and compact star points to the necessity of a softer equation of state (EoS), in tension with the requirement of a stiff EoS to support massive pulsars above 2 solar mass. In this work, we investigate the possibility that HESS J1731-347 may be realized as a hybrid star (HS) containing deconfined quark matter in its inner core. Within the Constant Speed of Sound (CSS) parametrization, we systematically study the influence of individual parameters and hadronic properties—such as the effective nucleon mass, nuclear symmetry energy, and its slope at saturation—on the stability and structure of such low-mass compact stars. Our analysis shows that, at the 1 sigma credible level, HESS J1731-347 is consistent with a stable HS featuring early deconfinement and a sizable energy gap.

We further extend this framework by including dark matter (DM) interactions in both the hadronic and quark sectors, examining their role in modifying stellar properties. The presence of DM inside hybrid stars leads to significant modifications in the mass–radius relation and opens new possibilities for explaining the observed properties of HESS J1731-347.

Overall, our results suggest that the combined effects of dense matter physics, phase transitions, and DM interactions provide a viable path toward reconciling low-mass compact star observations with the existence of massive pulsars.

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