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Quarkonium Spectroscopy in the Quark-Gluon Plasma

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The properties of bound states are fundamental to hadronic spectroscopy and play a central role in the transition from hadronic matter to a quark-gluon plasma (QGP). In a strongly coupled QGP (sQGP), the interplay of temperature, binding energy and large collisional widths of the partons poses formidable challenges in evaluating the in-medium properties of hadronic states and their eventual melting. In particular, the existence of heavy quarkonia in the QGP is a long-standing problem that is hard to solve by considering their spectral properties on the real-energy axis. We address this problem by analyzing in-medium thermodynamic quarkonium T-matrices in the complex energy plane. We first validate this method in vacuum, where the T-matrix poles of observed states are readily identified. When deploying this approach to recent self-consistently calculated T-matrices in the QGP, we find that poles in the complex energy plane can persist to surprisingly large temperatures, depending on the strength of the in-medium interactions. While the masses and widths of the pole positions are precisely defined, the notion of a binding energy is not due to the absence of thresholds caused by the (large) widths of the underlying anti-/quark spectral functions. Our method thus provides a new and definitive quantum-mechanical criterion to determine the melting temperature of hadronic states in the sQGP while increasing the accuracy in the theoretical determination of transport parameters.

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