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Bound states and resonances in thermal models

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We study the thermal properties of scalar quantum field theories (QFTs) involving 3-leg and 4-leg interaction terms, with special attention on the role of bound states and resonances. Within a suitable unitarization scheme, for which the employed QFT is unitary, finite, and well defined for each value of the coupling constant, we calculate the scattering phase shifts, whose derivatives are used to infer the pressure of the system at nonzero T. A bound state emerges in each when the attraction is strong enough, but we show that it does not count as one state in the thermal gas, since a cancellation with the residual scattering interaction typically occurs. The amount of this cancellation depends on the details of the model and its parameters: a variety of possible scenarios is presented. Moreover, even when no bound state occurs, we estimate the role of the interaction in general and of resonances in particular.

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