High-precision equations of state for solar modeling

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For models of the Sun and Sun-like stars, a high-quality equation of state is crucial. Conversely, helioseismic and asteroseismic observations put constraints on the physical formalisms. Thus they effectively turn the Sun and the stars in laboratories for dense plasmas. As far as models of the Sun and Sun-like stars are concerned, two of the major efforts for a high-precision and high-accuracy equation of state were made in the context of recent opacity recalculations: (1) the OPAL opacity project of Livermore and (2) the Opacity Project OP, an international consortium. The former is based on the activity-expansion ACTEX, the latter on the Mihalas-Hummer-Däppen (MHD) equation of state. While OPAL has a solid theoretical foundation, and is so far the best match of the observational data, MHD has other advantages since it is more intuitive, easy to realize, and allows adjustable parameters. Furthermore, MHD is an open-source product, in contrast to the proprietary OPAL. Recently, a version of MHD has been obtained by implementing the so-called "Plank-Larkin partition function" and by adding scattering-state terms. The resulting formalism matches OPAL well. We review these developments and other options for solar modelers.

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