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Testing the helioseismic determination of opacity corrections

S.C. Tripathy

Udaipur Solar Observatory, Physical Research Laboratory, PO Box No. 198, Udaipur 313 001, India

J. Christensen-Dalsgaard

Teoretisk Astrofysik Center, Danmarks Grundforskningsfond, and
Institut for Fysik og Astronomi, Aarhus Universitet, DK-8000 Aarhus C, Denmark

Abstract. By constructing solar models with two different opacity tables, it is shown that helioseismic determination of corrections to the opacity κ is possible, although only to within a constant shift in log κ.

Key words: helioseismology, solar oscillation, opacity

Tripathy *et al.* (1997) showed that corrections to opacity can be determined helioseismically, by fits to the sound-speed difference between the Sun and a reference model obtained from inversion of observed frequencies. Here we test this procedure on artificial data, by constructing two solar models with different opacity tables. The reference model was computed with Cox and Tabor (1976) opacities while the test model used the Los Alamos Opacity Library (Huebner et al. 1977). The fitted intrinsic opacity correction, at fixed temperature, density and composition, based on the sound-speed difference between these two models is shown by the solid line in Figure 1. The dashed line shows the actual difference between the two tables, through a solar model, while the dotted line is the inferred difference but shifted in $\delta \ln \kappa$. It is evident that with this shift the agreement is satisfactory, except at the limits of the range. Thus, to this extent the test is quite successful.

To demonstrate that the sound speed in calibrated solar models is almost unaffected by a constant shift in $\log\kappa$, Figure 2 shows difference between a test model computed with a constant increase of $\delta \log\kappa = 0.01$ and an unmodified reference model. The models have been calibrated to solar luminosity by adjusting the initial hydrogen abundance. The opacity modification clearly has little effect on the sound speed: the temperature change is largely compensated by the change in composition resulting from the calibration. Therefore, we conclude that, given the flexibility of the calibration, the helioseismic determination of the opacity correction is possible only within a constant factor in κ.

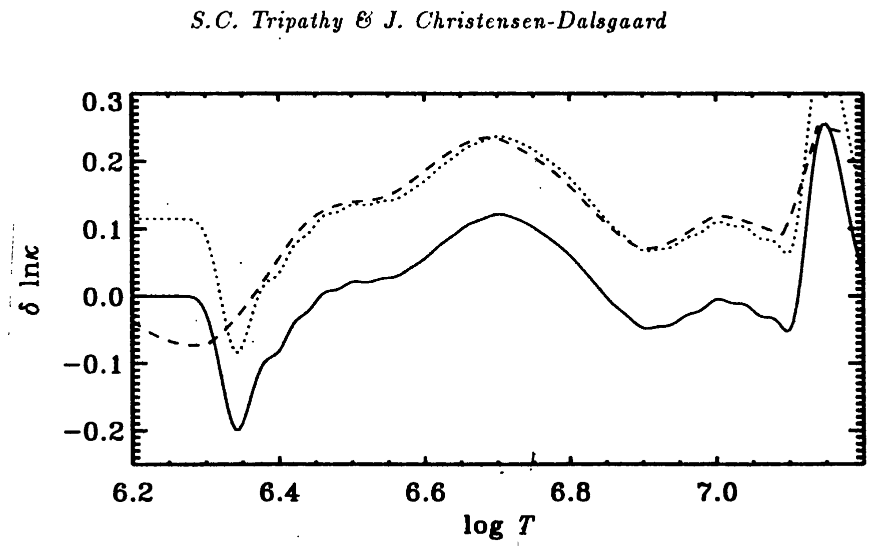

Figure. 1. The dashed line is the actual intrinsic opacity difference between CT and LAOL opacities. The solid line is the opacity difference as inferred from fitting the sound-speed difference between the models. The dotted line is the same but shifted to obtain a decent match with the actual difference.

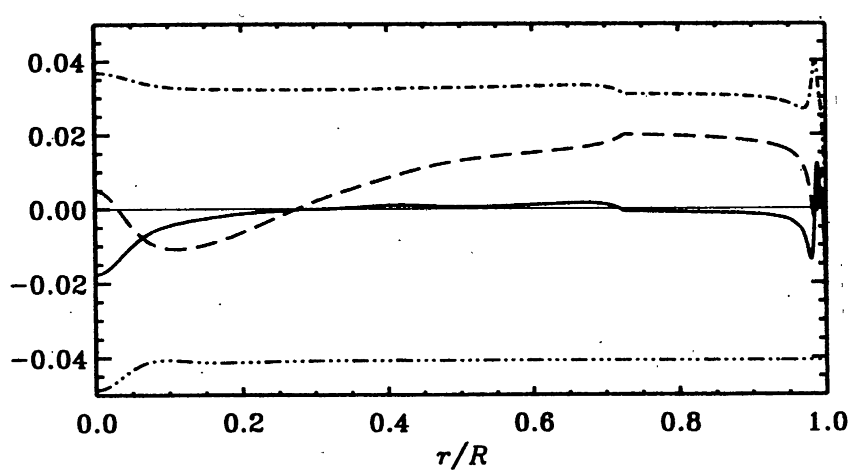

Figure. 2. The effect of a constant opacity increase of $\delta \log_{10}\kappa=0.01$ in an evolution calculation. Solid, dashed, dot-dashed and triple-dot-dashed lines show the relative differences in squared sound speed, density and temperature, and the difference in hydrogen abundance, respectively.

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