Helioseismic inference of the solar radiative opacity

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The Sun is the most studied of all stars and constitutes a benchmark for stellar models. However, our vision of the Sun is still incomplete, as illustrated by the current debate on its chemical composition [1,2]. The problem reaches far beyond chemical abundances and is intimately linked to microscopic and macroscopic physical ingredients of solar models such as radiative opacity (see e.g. [3] for a review), for which experimental results have been recently measured that still await theoretical explanations. We present for the first time opacity profiles derived from helioseismic inferences and compare them with detailed computations of individual element contributions using four different opacity codes (OPAS, OP, SCO-RCG and OPLIB) in a complementary way to experimental results. We find that our seismic opacity is ~10% higher than theoretical values used in current solar models around 2 million degrees, but lower by 35% than some available theoretical values (See Figure 1 below). Using the Sun as a laboratory of fundamental physics [4], we show that quantitative comparisons between various opacity tables are required to understand the origin of the discrepancies between reported helioseismic, theoretical and experimental opacity values.

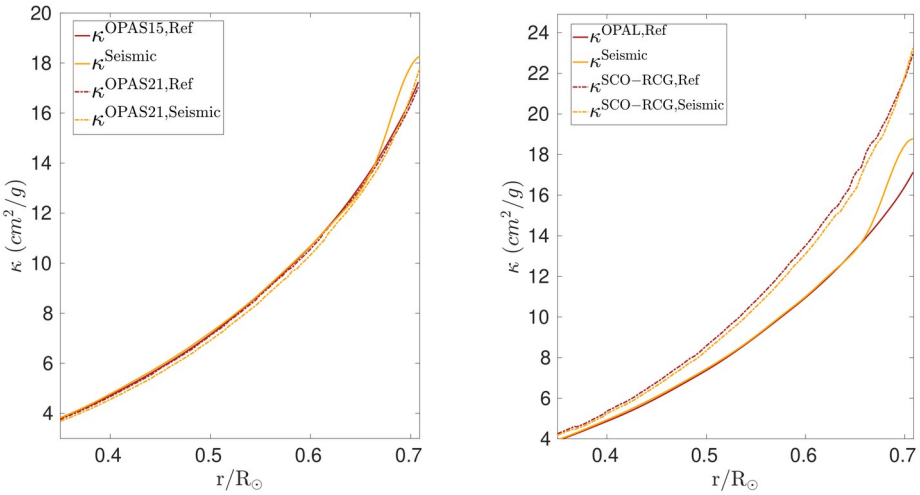

Figure 1. Comparison of the mean Rosseland opacity profiles of solar models, seismic reconstruction and theoretical computations for the thermodynamical. *Left panel:* Opacity profiles from evolutionary computations with 2015 OPAS tables (brown-plain line), from seismic reconstruction (orange-plain line), and from detailed computations with the OPAS code for both model and seismic thermodynamical paths (brown and orange dashed lines, respectively). *Right panel:* Opacity profiles for evolutionary computations using OPAL tables (brown-plain line), from seismic reconstruction (orange-plain line) and from detailed SCO-RCG computations for both model and seismic thermodynamical paths (brown and orange dashed lines, respectively).

References

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