Quick notes on
Oscillator Strengths

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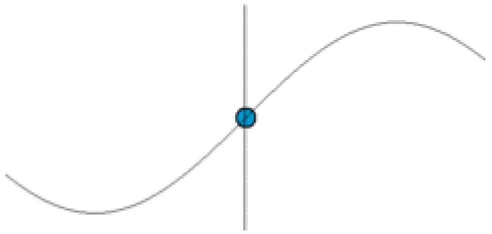
Ohio University - ASTR4201 - Fall 2020

Semi-classical picture of absorption



- Visualize photon absorption corresponding to a given bound-bound transition as a photon oscillating an electron which is disturbed to result in the atomic transition
- The EM field drives the oscillator and Larmor radiation damps it
- TBS shows that the corresponding classical cross section results in

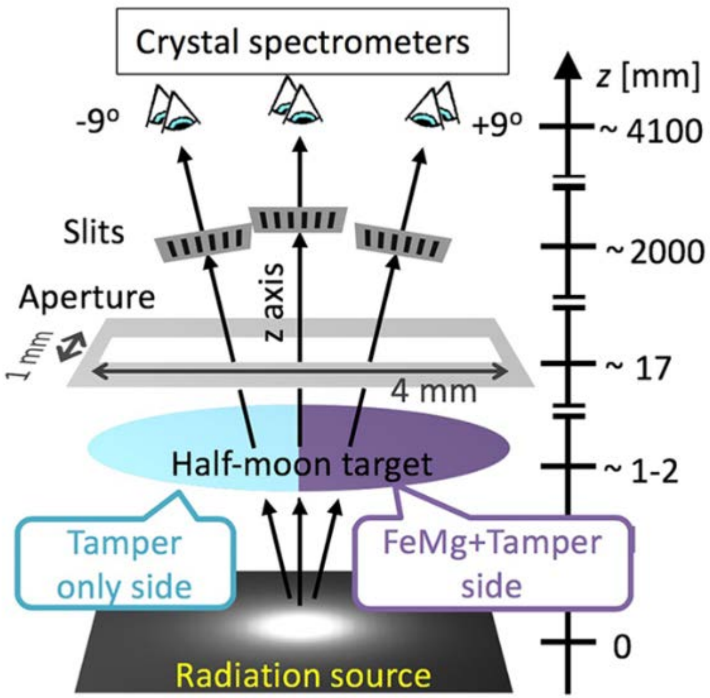
$$\frac{1}{l_{mfp,\nu}} = \kappa_\nu \rho = n\sigma = n_{\mathrm{ion},n}\left(\frac{\pi e^2}{m_e c}\right)\left(\frac{\Gamma/4\pi}{(\nu_0-\nu)^2+(\Gamma/4\pi)^2}\right) f_{mn}$$

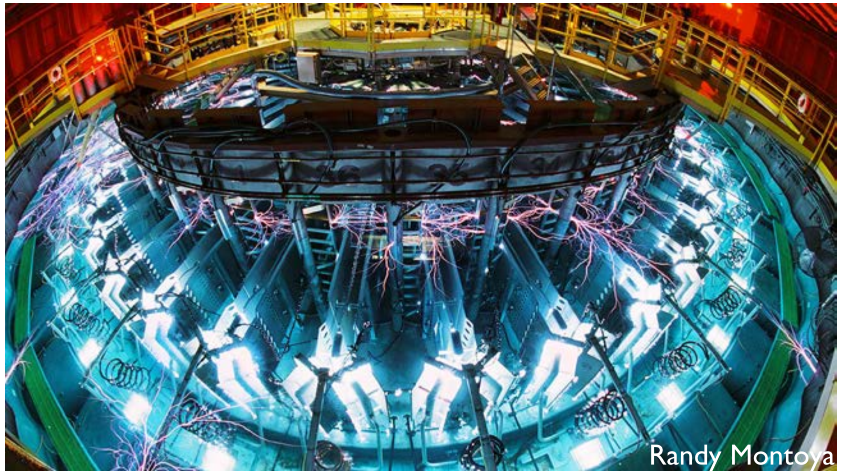
for a transition from state n to m

- f_{mn}, the oscillator strength, scales the absorption cross section relative to the classical estimate
- For $n \rightarrow m$, $f_{mn} = \frac{2}{3}\frac{m_e}{g_n \hbar^2 e^2}(E_n - E_m)\left|\langle m|\hat{d}|n\rangle\right|^2$
- $\sum_m f_{mn} = N$ electrons in the atom.

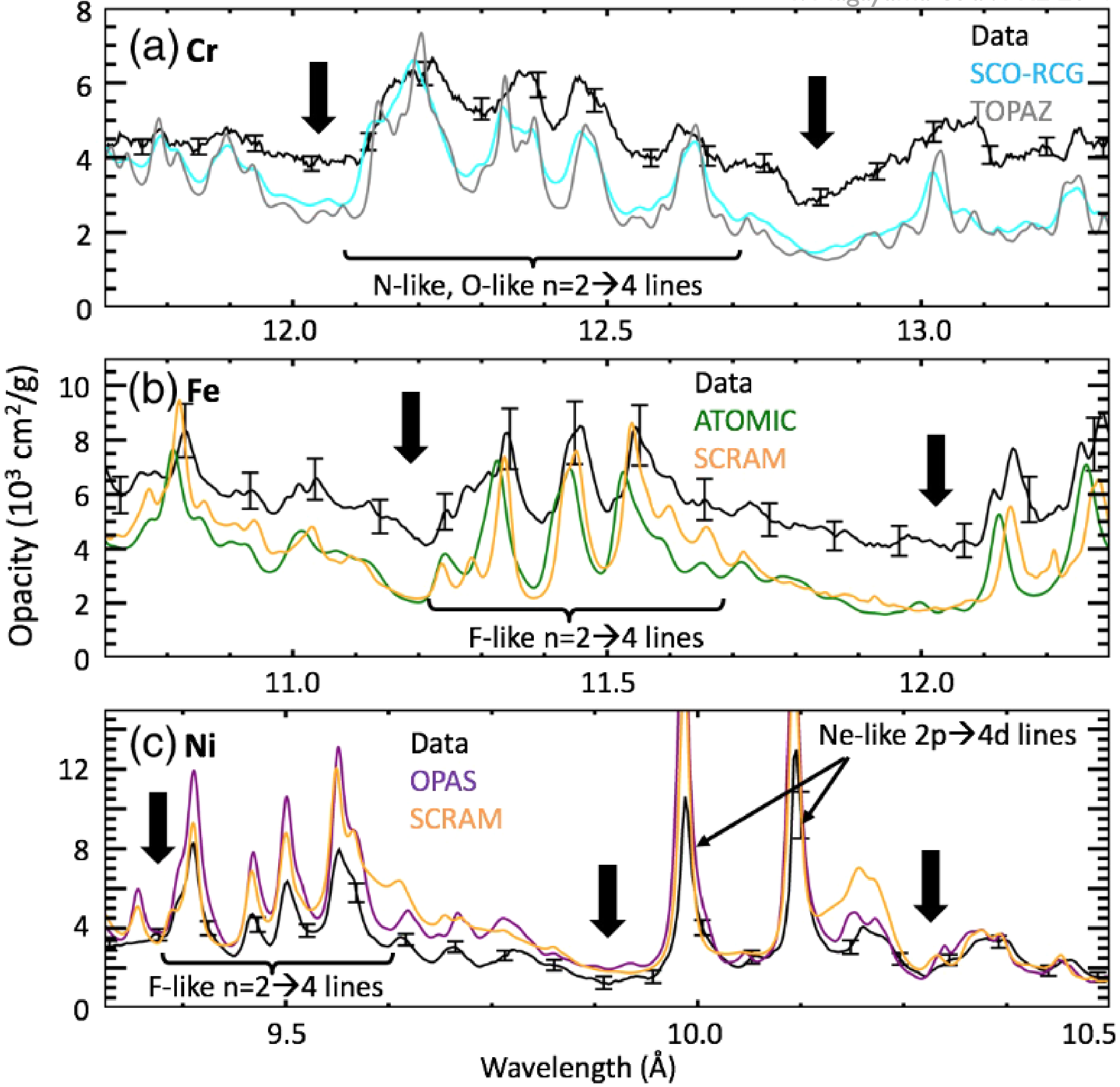
Emission f_{mn} contribute to the sum and are negative

Confronting Calculations with Reality

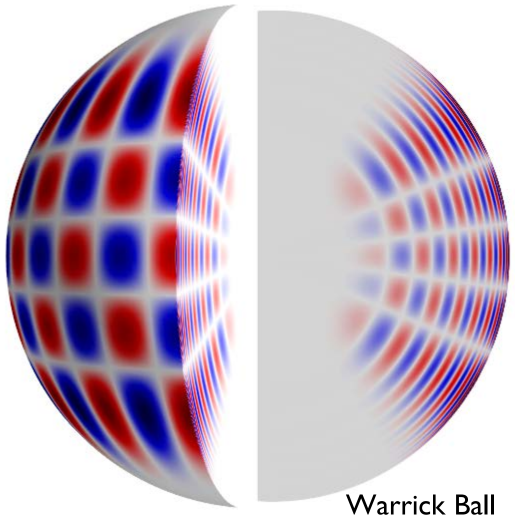




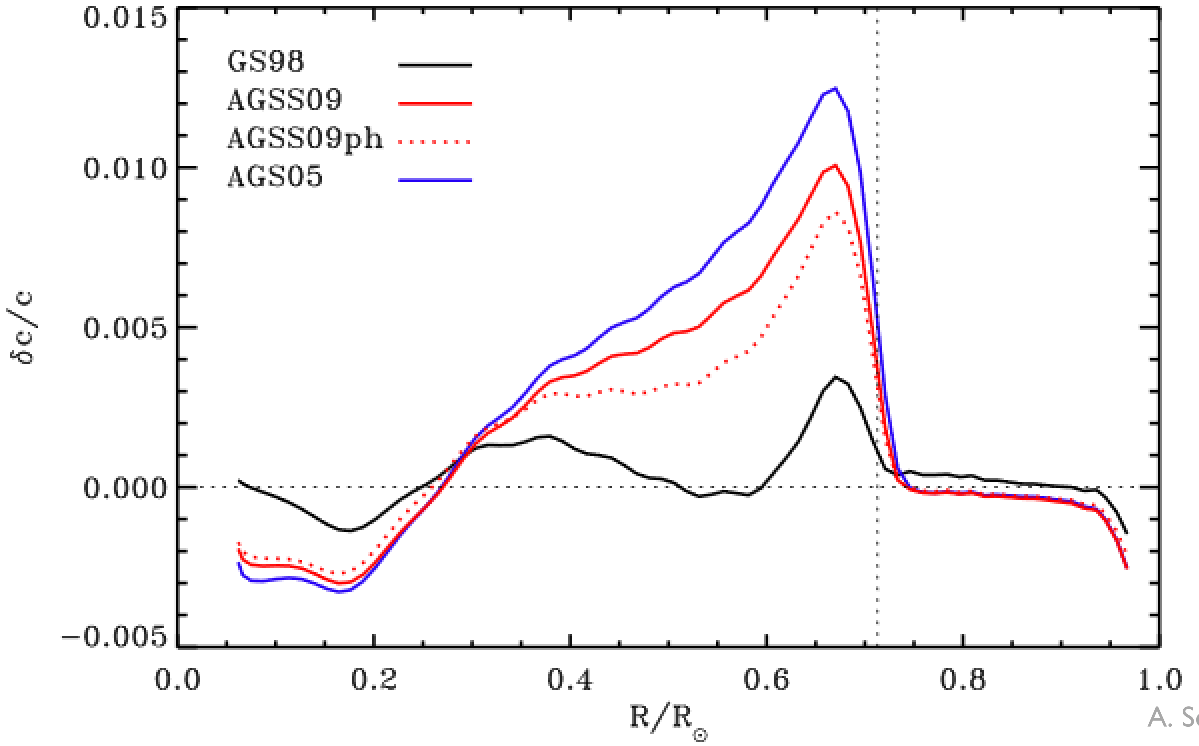
T. Nagayama et al. PRL 2019

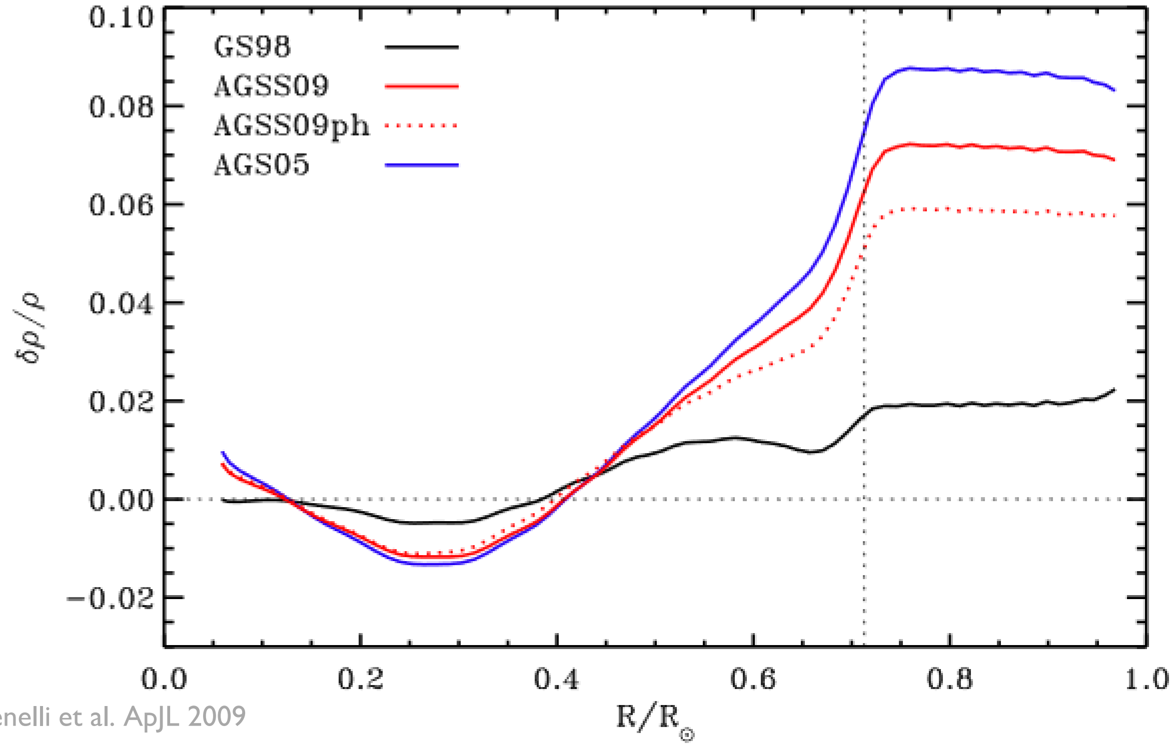


The Solar Modeling Problem



- Solar models constructed with observed solar abundances and calculated+measured opacities are in tension with the solar structure determined from helioseismology
  - E.g. Convective/Radiative heat transport boundary differ by 11σ
- Standard solar model also discrepant with solar neutrino fluxes





A. Serenelli et al. ApJL 2009