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Optically-Thin Line-of-Sight Spectroscopy: What Are You Really Measuring?

Or: ***The Effect of Non-Equilibrium Ionization and the Solar Wind on the Broadening of Coronal Emission Lines***

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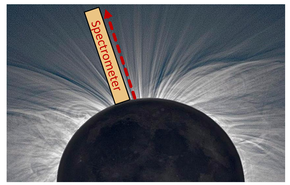
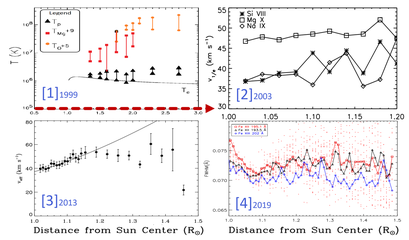
Introduction + Background

Case Study: The Solar Corona

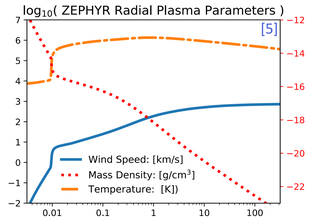


1. Slit spectrometers measure spectral lines as a function of position.



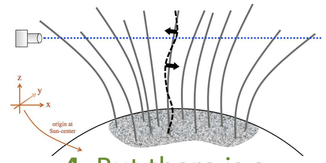
2. We have used them for decades to observe the Sun's atmosphere (The Corona).

We study the both the intensity and the width of the spectral lines.



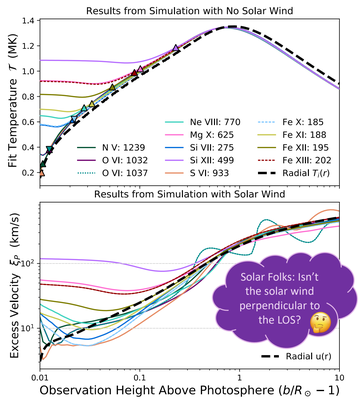
3. We want to measure radial variation of plasma.

How does the temperature, or solar wind speed, change with height?



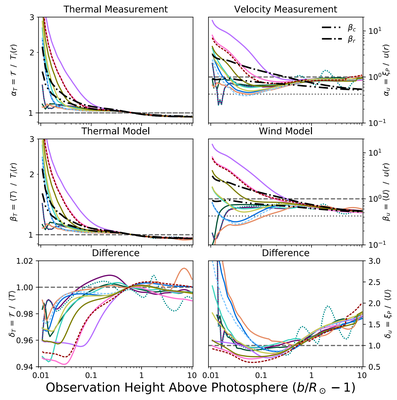
4. But there is a Line-of-Sight Problem.

In an optically thin system, observations contain light from the whole column. Commonly called a "Line-of-Sight Average."



5. Simulated measurements probe radial variation only for some regions and some ions.

Others show very strong departures.



6. Measurements are probing an emissivity-weighted average of the quantities.

$$\langle T \rangle = \frac{\int_{-s}^{s} J\ T_i\ dx}{\int_{-s}^{s} J\ dx} \qquad \langle U \rangle = \frac{\int_{-s}^{s} J\ \vec{u} \cdot \hat{n}_{los}\ dx}{\int_{-s}^{s} J\ dx}$$

This research was performed in python using **GHOSTS**: the Global Heliospheric Optically-thin Spectral Transport Simulation, written by Chris R. Gilly.

The **most dense plasma** in an optically-thin observation **isn't always the brightest** part of the line-of-sight.

Position along a slit **is not** always **correlated with** measurement **location.**

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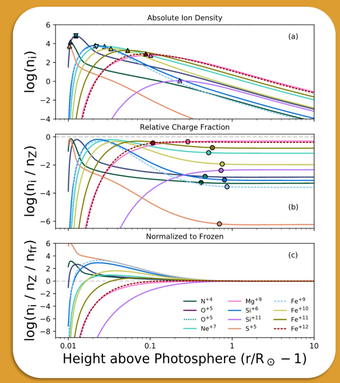
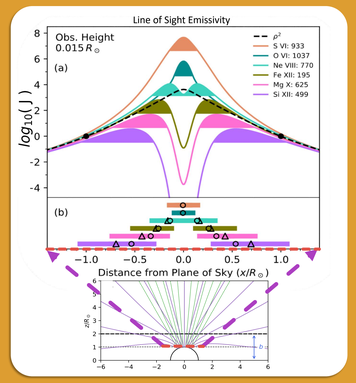
See my Work! This poster and more at my website: *www.gilly.space*

Discovery: Measurement Floors

"**Line-of-Sight Averaging**" doesn't just skew the results, it **changes the effective measurement location.**



7. Temperature gradients cause strong population change.



8. Measuring lower doesn't actually probe lower in the corona.

Lessons for Anyone

When doing spectroscopy, make sure you understand what the **ion density** is doing separately from the total density. **Ionization effects are often dominant within temperature gradients.**

Be careful in interpreting your data in the presence of any effects that change the population of the particle you are observing independent of total density variation.

References: [1] Esser et al. 1999, ApJ, 510, L63; [2] Moran 2003, ApJ, 598, 657; [3] Hahn & Savin 2013, ApJ, 763, 106; [4] Del Zanna 2019, A&A, 624; [5] Cranmer 2007, ApJs, 171, 520

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