

A Solution of the Open Flux Problem: Diminished Zeeman Splitting

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Quick Summary

Problem: Extrapolated open magnetic flux measured in the photosphere is significantly less than in-situ measurements of heliospheric flux.

There is no consensus solution.

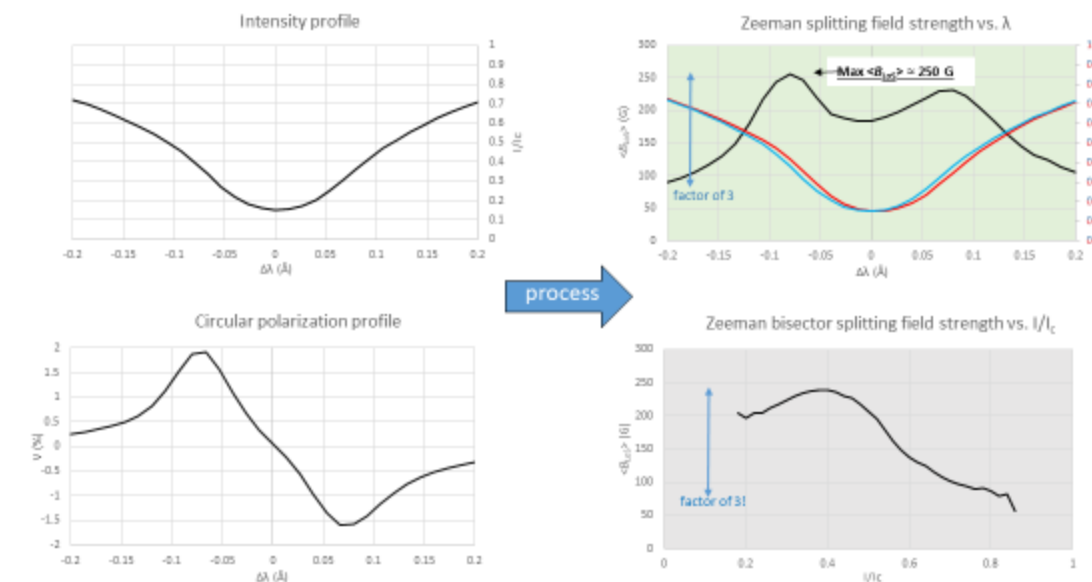
A solution: The line-of-sight magnetic flux densities inferred from circular polarization profiles of Zeeman-split spectral lines are usually diminished. This loss of detectable flux causes the open flux problem.

Measuring with a strong line mitigates the open flux problem.

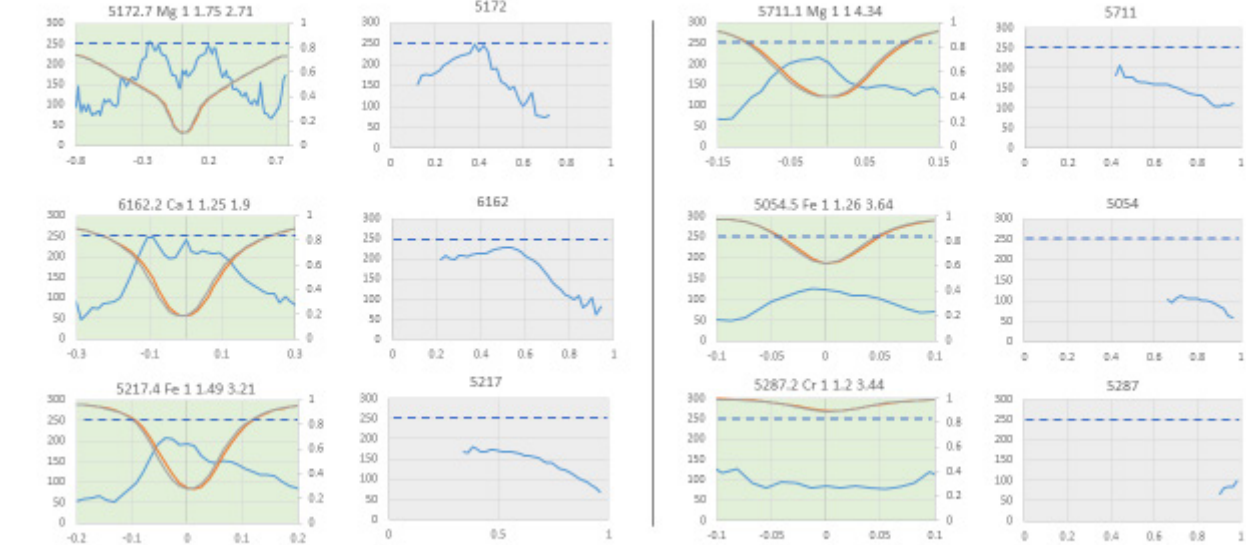
1. Observations and Measurements

- Plage and network features were observed with the Kitt Peak Fourier Transform Spectropolarimeter
- Intensity (I) and circularly polarized (V) spectra were simultaneously observed over the range 4924-6772 Å with >350,000 resolution
- Spectra of 200 lines were reduced to Zeeman splitting and bisector splitting profiles expressed as line-of-sight magnetic flux density averaged over the observing aperture $\langle B_{LoS} \rangle$

2. Sample profiles (Fe I 5232.9 Å)

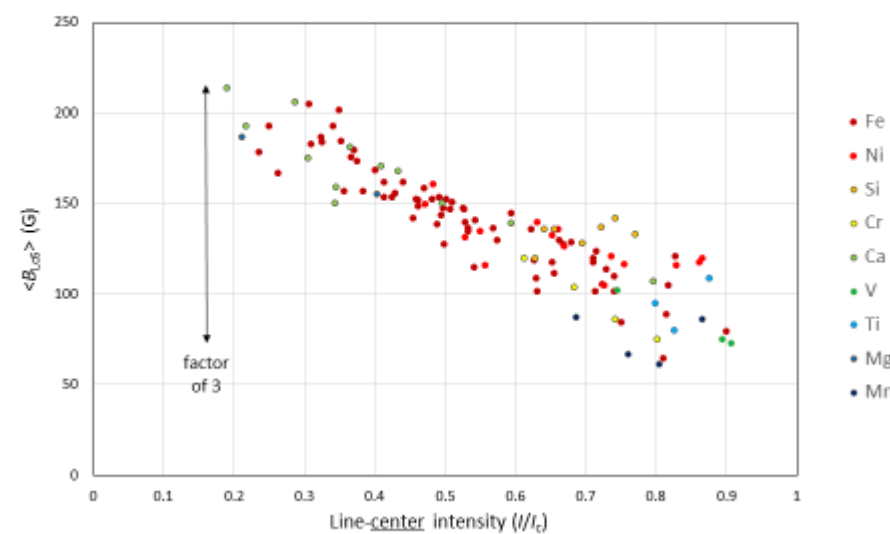


3. Typical $\langle B_{LoS} \rangle$ vs. line strength

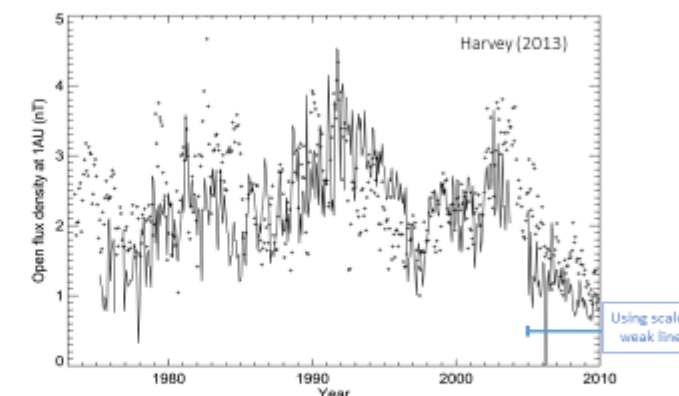
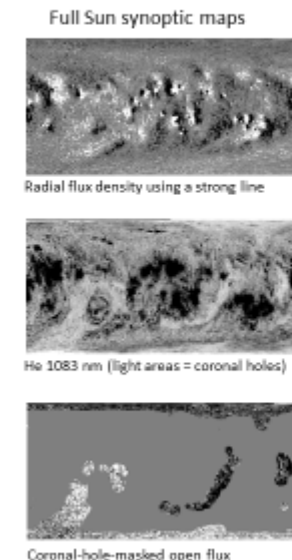


4. Weak spectrum lines \rightarrow weak flux

(Bisector Zeeman splitting $\langle B_{LoS} \rangle$ @ half line depth)



5. Open flux problem mitigated using a strong line



- Carrington rotation averages of open flux density
- + symbol = in-situ measurements at 1 au
- Line = 1 au extrapolation of photospheric flux in He 1083 nm coronal holes
- \Rightarrow No major open flux problem!

6. Key Results

- Measured the line-of-sight Zeeman splitting in 200 diverse spectral lines
- Maximum of derived $\langle B_{LoS} \rangle$ found at $I/I_{\text{continuum}} \approx 0.4$
- $\langle B_{LoS} \rangle$ typically diminishes at other intensities by up to a factor of 3
- Confirmed by independent observations (not shown here)

Most observations underestimate photospheric magnetic flux.
How the flux hides from detection is an unsolved problem.
Observing with a strong line largely solves the open flux problem.

A detailed paper is in preparation
(see also Wang, Ulrich & Harvey 2022, ApJ 926, 113)