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# How to make the Sun look less like the Sun and more like a *(distant)* star?

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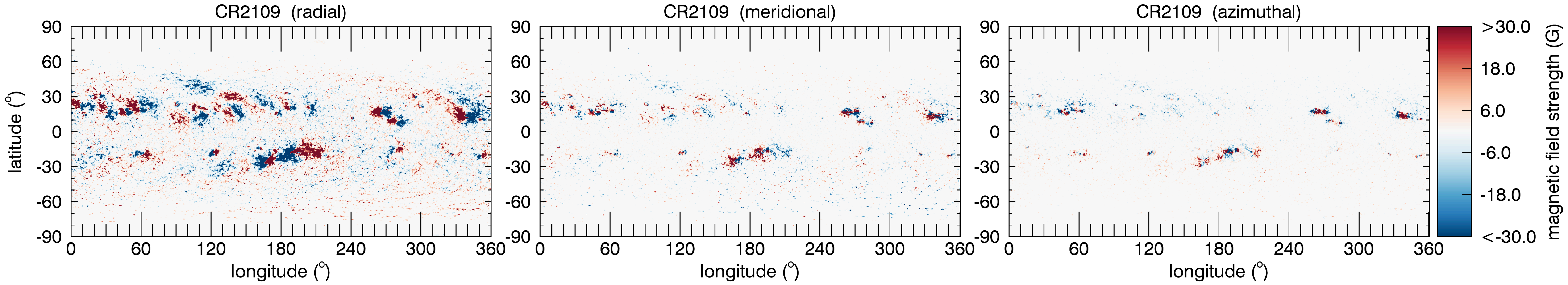
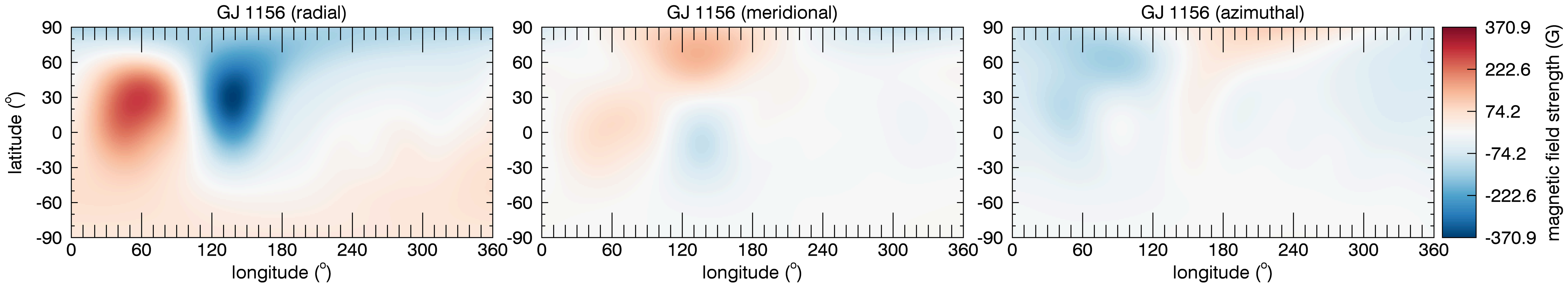
- Direct comparison between stellar and solar magnetic maps are hampered by their dramatic differences in resolution. Using the maximum degree $\ell_{max}$ of spherical harmonics as proxy for spatial resolution, we have:

Solar vector map: $\ell_{max}$ >150 (Gosain et al 2013)




Vector map of the M dwarf star GJ 1156: $\ell_{max}$=6 (Morin et al 2010)




- **Goal**: Devise a way to compare high-resolution magnetic maps of the Sun with low-resolution maps of stars.

- **Method**: Use the formalism from Zeeman Doppler Imaging studies to decompose the magnetic field using spherical harmonics $Y_{\ell m}$ (degree $\ell$, order $m$).

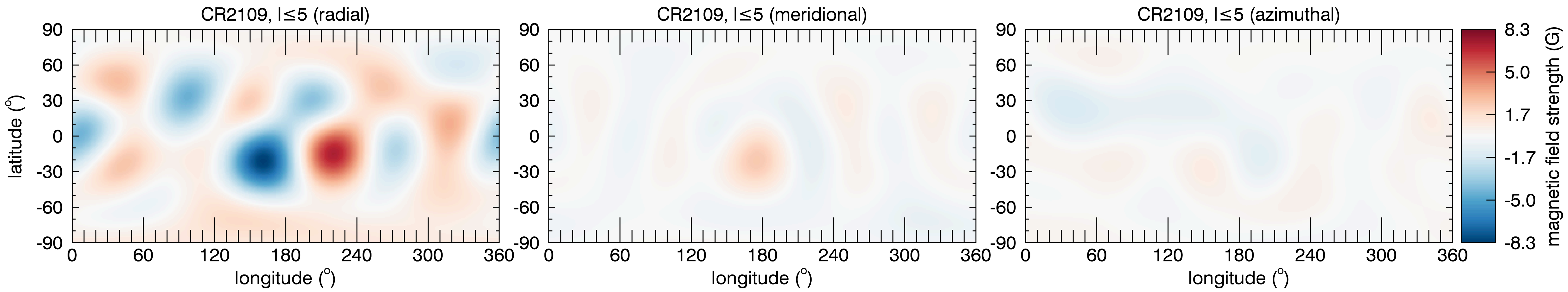
$$B_r(\theta,\varphi) = \sum_{\rm lm} \alpha_{\rm lm} Y_{\rm lm}(\theta,\varphi) \quad \text{radial}$$

$$B_\theta(\theta,\varphi) = \sum_{\rm lm} \frac{\beta_{\rm lm}}{l+1}\frac{\partial Y_{\rm lm}(\theta,\varphi)}{\partial\theta} + \frac{\gamma_{\rm lm}}{(l+1)\sin\theta}\frac{\partial Y_{\rm lm}(\theta,\varphi)}{\partial\varphi} \quad \text{meridional}$$

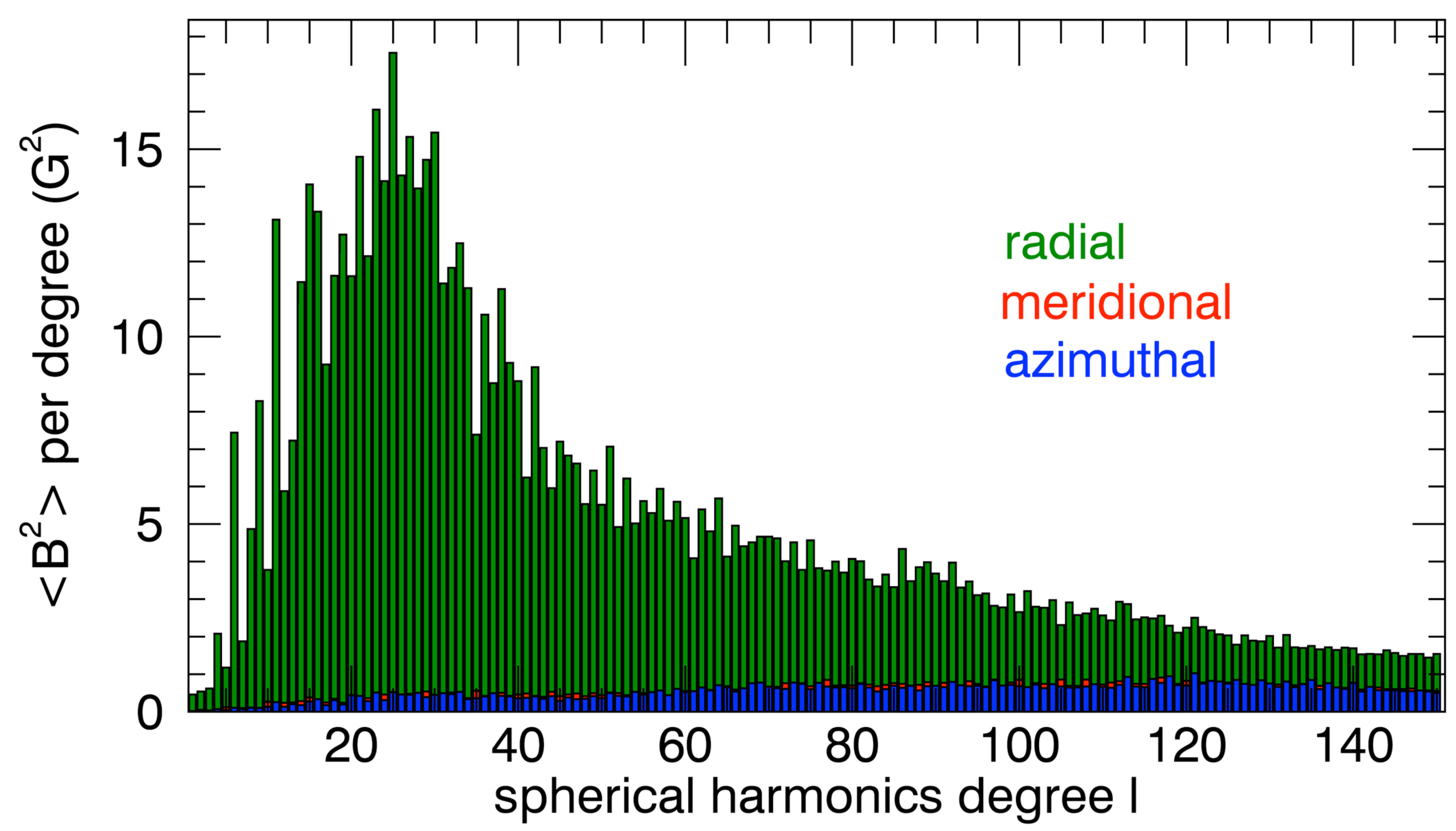
$$B_\varphi(\theta,\varphi) = -\sum_{\rm lm} \frac{\beta_{\rm lm}}{(l+1)\sin\theta}\frac{\partial Y_{\rm lm}(\theta,\varphi)}{\partial\varphi} - \frac{\gamma_{\rm lm}}{l+1}\frac{\partial Y_{\rm lm}(\theta,\varphi)}{\partial\theta} \quad \text{azimuthal}$$

- Equations are inverted to obtain $\alpha_{\ell m}, \beta_{\ell m}, \gamma_{\ell m}$.
- By restricting the sums to low-$\ell$ degrees, we can filter out the small-scale field, which is not assessable in stellar studies.

- **Results:** The solar magnetic field as seen from a "stellar" perspective: $\ell_{max}$=5




Distribution of magnetic energy at each $\ell$




- The peak at $\ell\approx25$ is related to spatial scales of ≈7°, which coincide with the size of active regions: active regions start to be resolved in the solar disc at $\ell\approx25$.

- **Conclusions**: Here, I presented a method to filter out the small-scale component of vector fields, so that comparison between solar and stellar large-scale magnetic fields can be *directly* made in *all* 3 components.
- This approach is entirely consistent with the description adopted in several stellar studies.
- The method can be used to confront synoptic maps synthesized in numerical simulations of dynamo and magnetic flux transport studies to those derived from stellar observations.

See also poster by Lisa Lehmann

Acknowledgements: The solar synoptic map in the top panel was acquired by SOLIS instruments operated by NISP/NSO/AURA/NSF.