PRIFYSGOL ABERYSTWYTH UNIVERSITY

Physics of outflows near solar active regions

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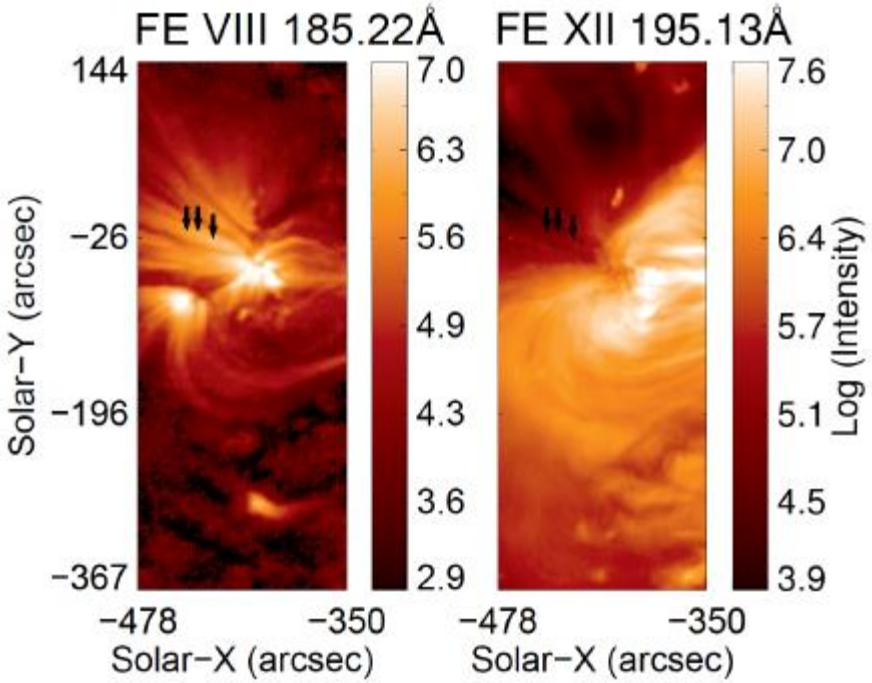
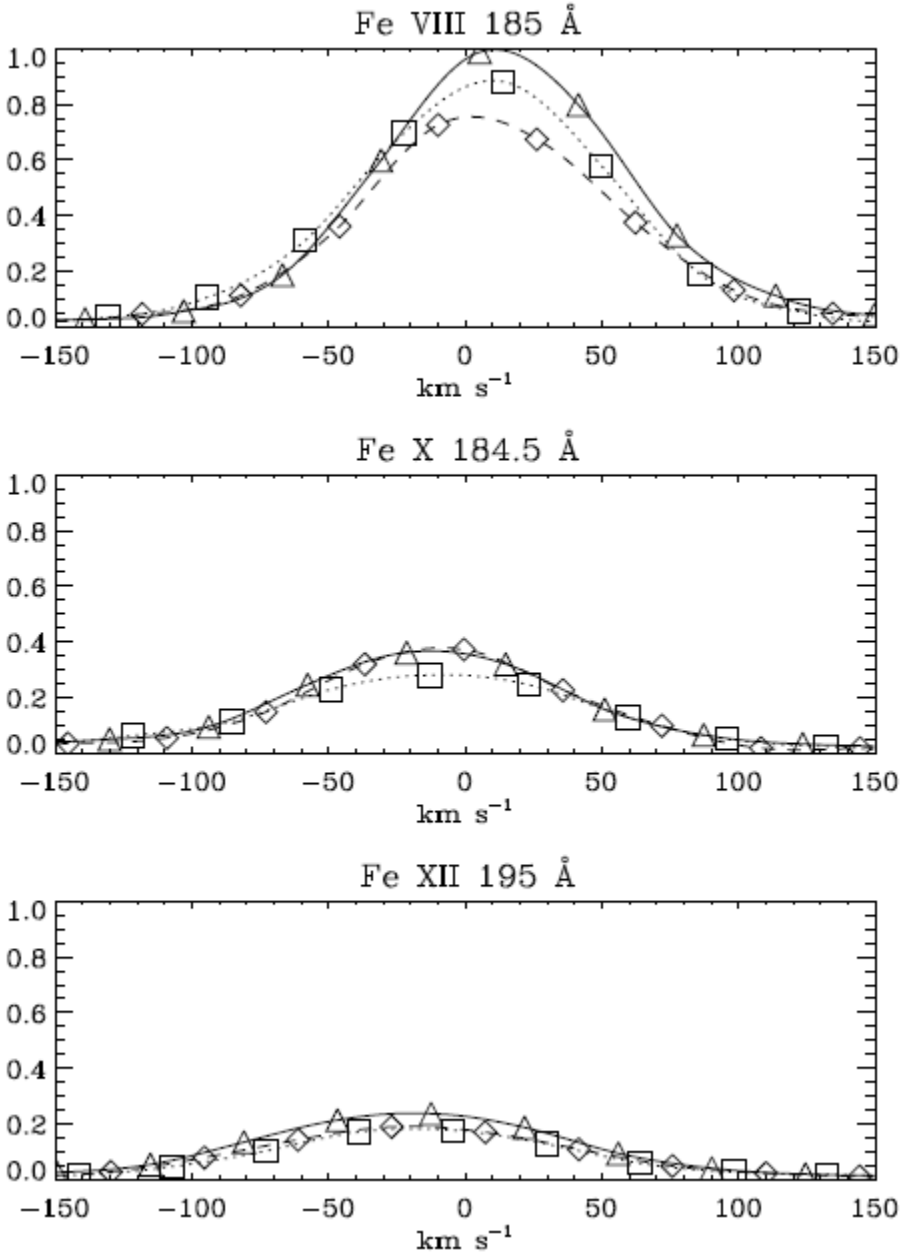
Solar System Physics
Ffiseg Cysawd yr Haul

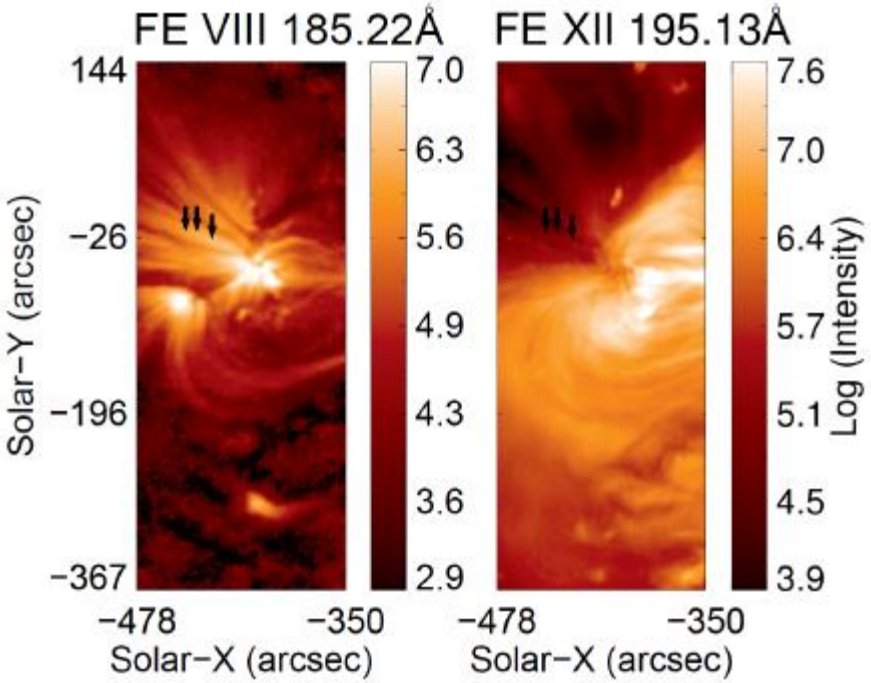
The Observations

- Hinode/EIS observations of an active region on 20th February 2007.
- Selected Fe VIII 185.21 Å, Fe X 184.54 Å, and Fe XII 195.12 Å spectral lines.
- See fan-like structures that become bright mainly in low temperature Fe VIII line.
- Connectivity unclear from small field of view. Either long loops or open structures.
- Selected three pixels from along a structure and plotted their line profiles.



The Observations





Methodology

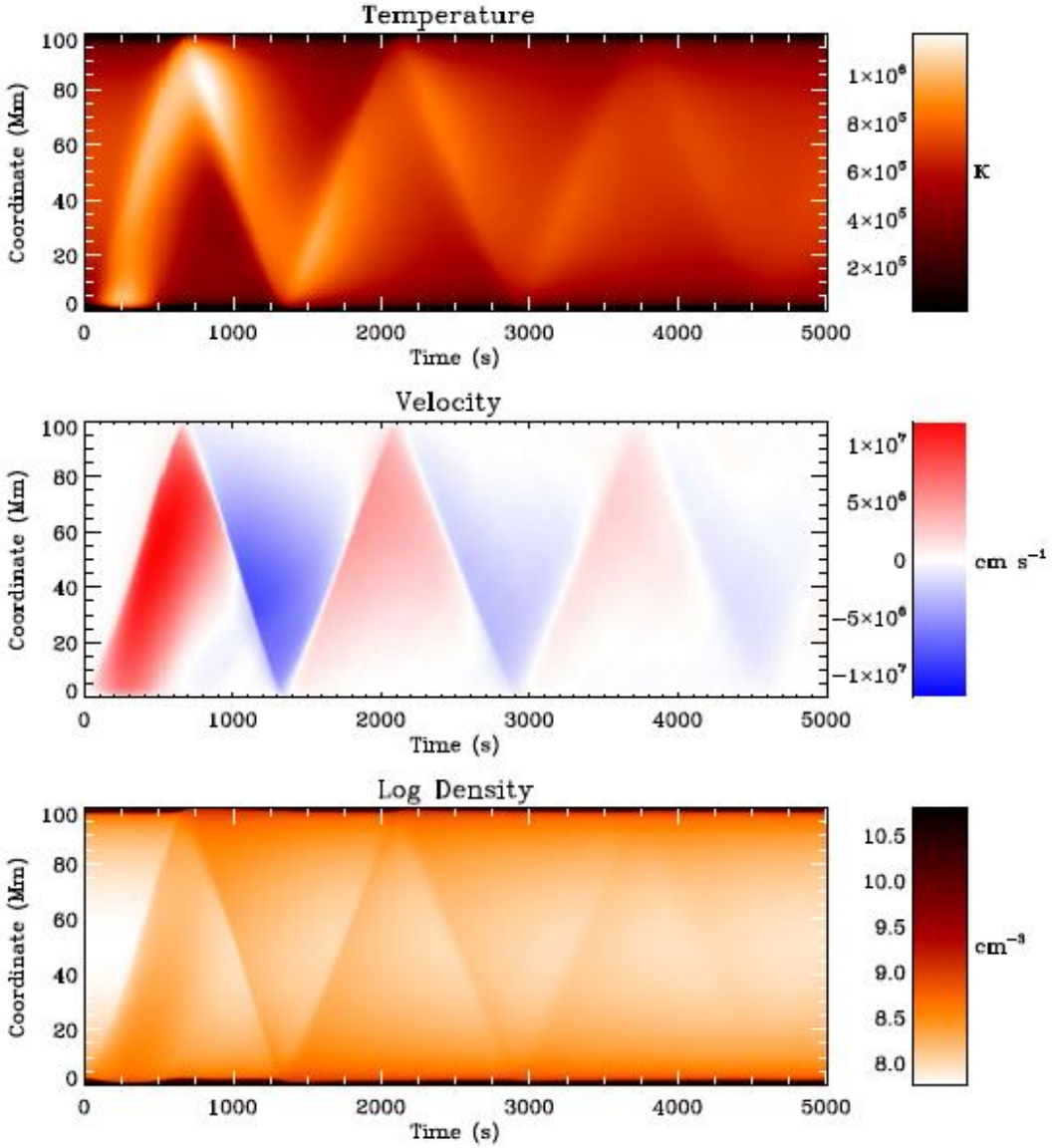
- We approximated the observed structure as a long loop and modelled it using the 1-D hydrodynamics and radiation code HYDRAD (Bradshaw & Cargill, 2013).
- The simulations factored in the 15 most abundant elements in the solar atmosphere.
- Elements considered to be in ionisation equilibrium when generating the initial conditions.
- Simulations then ran under non-equilibrium ionisation.
- The codes adaptive grid combined with this capability provides us with an accurate picture of the ions throughout the simulations.

Simulations & Modelling

- A single time-dependent heating pulse was injected into the top of the chromosphere at the first footpoint.
- Pulse parameters varied but its temporal profile always consisted of a linear increase from zero to maximum heating, a plateau, and then a linear decrease back to zero.
- Pulse injection occurred at the very start of the simulations, which ran until the loop had settled back into an approximation of its initial state.
- The physical and ion data were then forward modelled to create synthetic line profiles.
- We construct line profiles for a single thread, 10 superimposed threads, and 100 superimposed threads. Whereby each thread evolves identically but they are randomly offset in time.

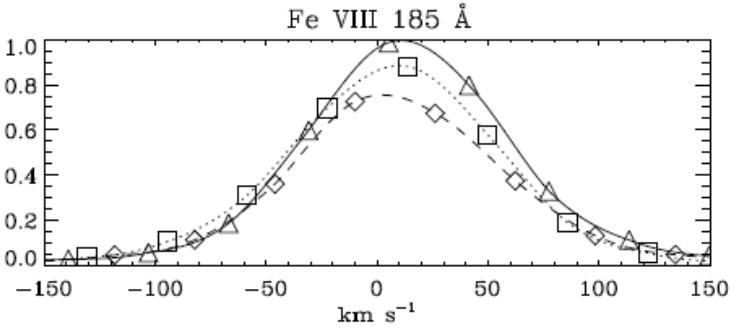
Physical Results

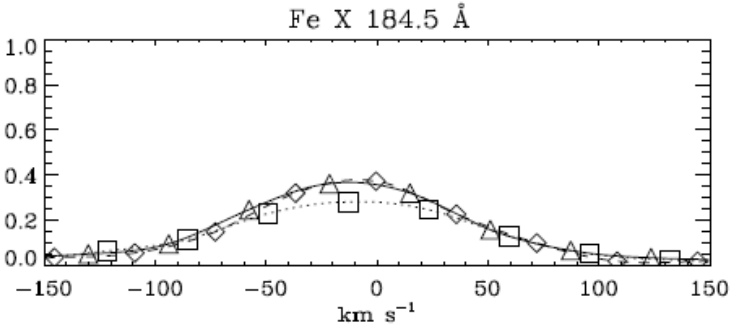
- Initial state in equilibrium prior to the event.
- Heating triggers evaporation of chromospheric material into the loop.
- Material flows to opposite footpoint, increasing temperature and density as it does so.
- Flow rebounds and travels back along the loop with much less energy.
- Returns to approximately initial state.

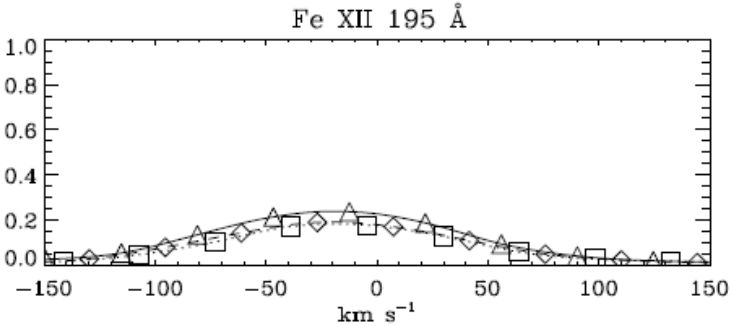


Modelling Results: monolithic loop

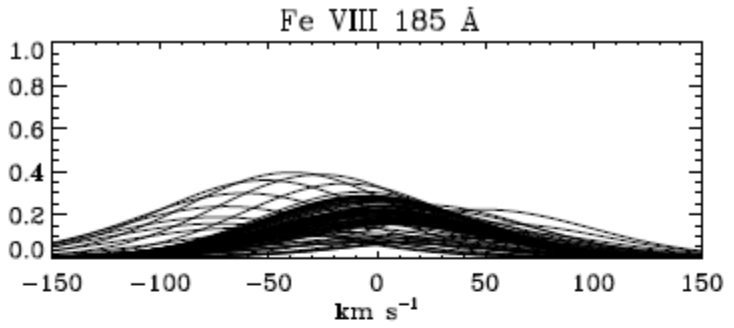
Observed

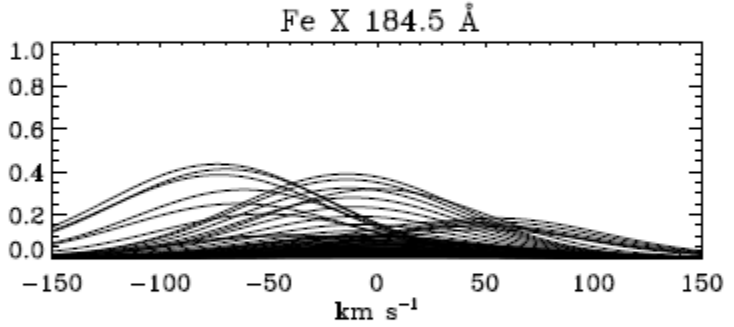


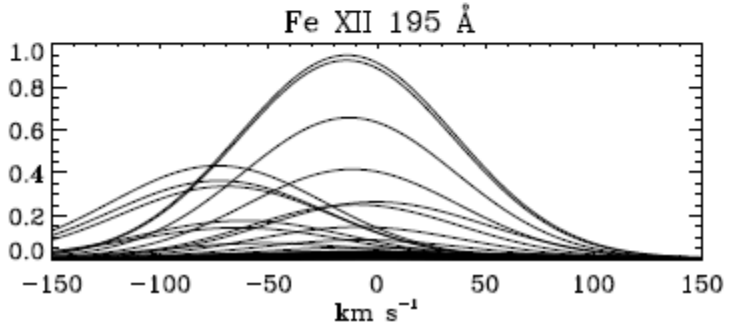




Modelled

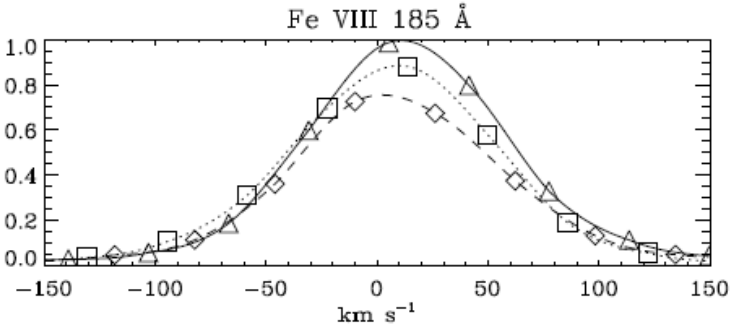


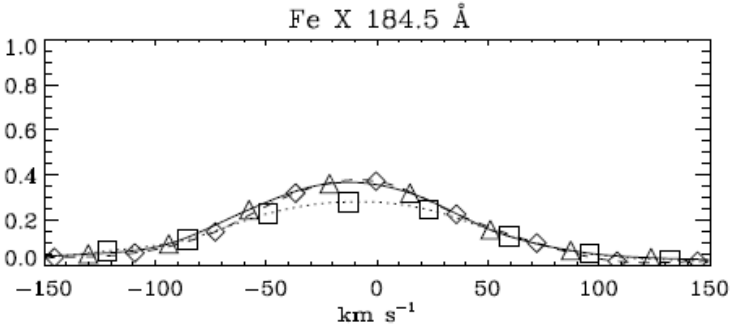


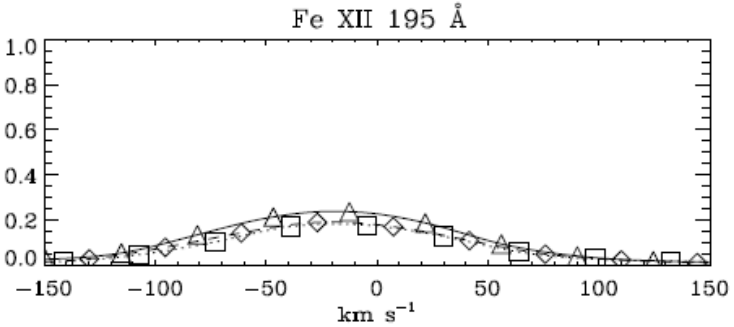


Modelling Results: 10 threads

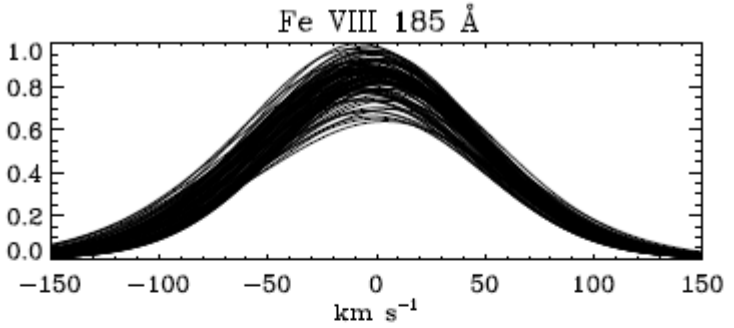
Observed

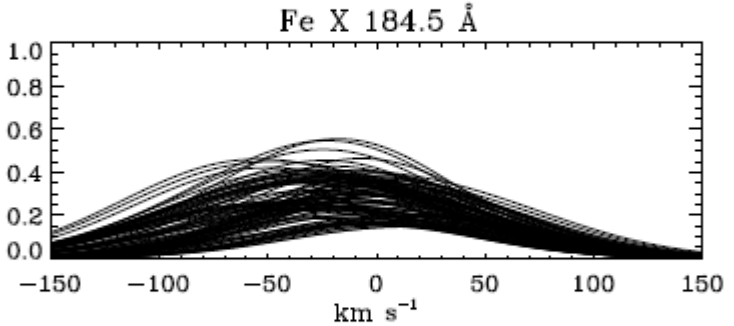


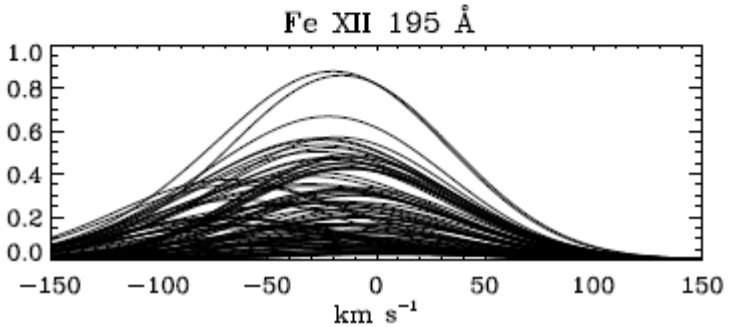




Modelled

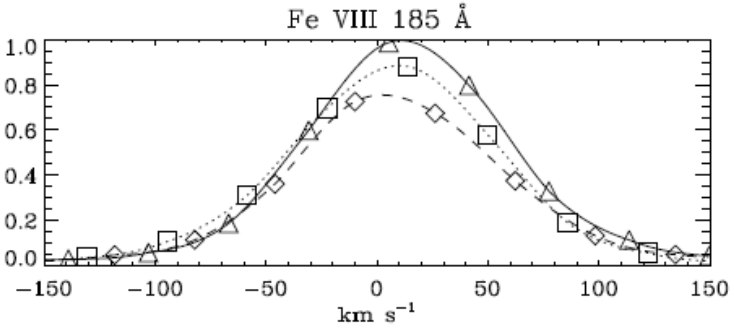


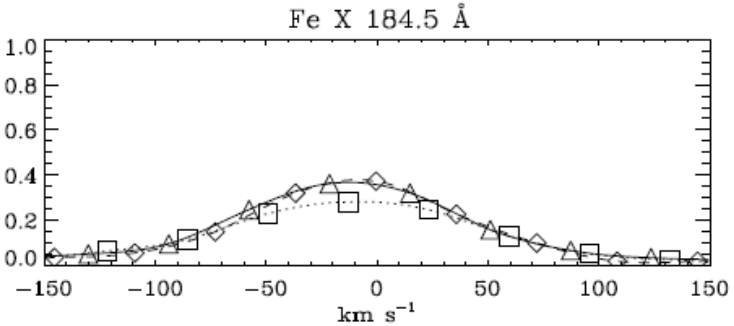


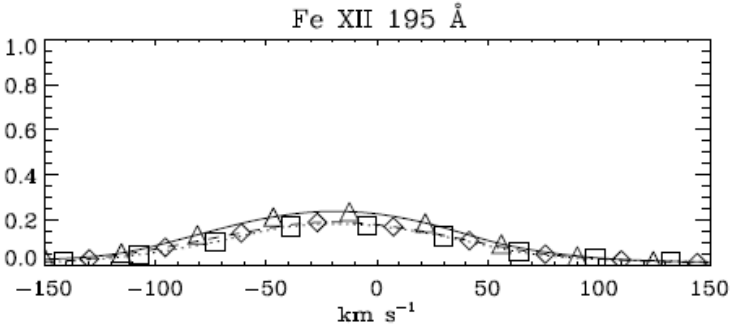


Modelling Results: 100 threads

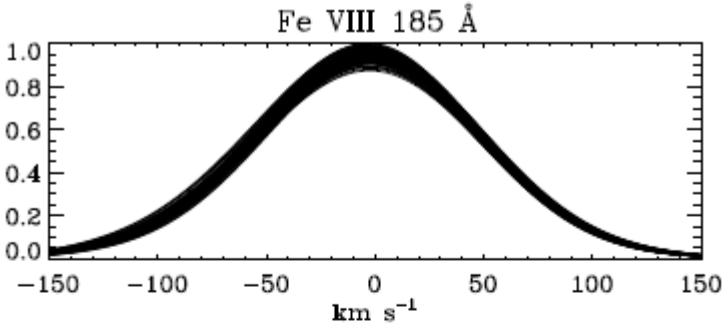
Observed

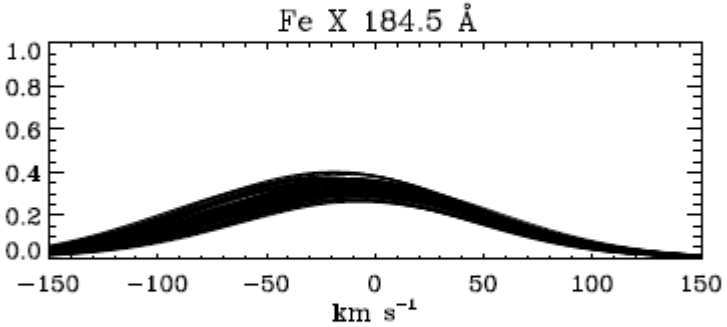


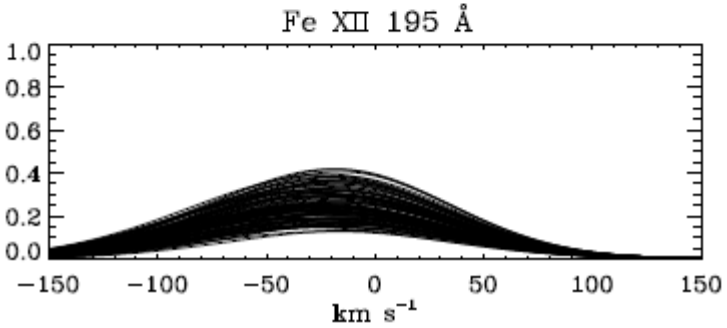




Modelled







Summary & Conclusions

- Carried out hydrodynamic simulations to determine the physical evolution of the observed structure and its parameters.
- Conducted forward modelling on the results to create artificial line profiles for comparison to the observed profiles.
- Similarities between the observed and modelled line profiles indicate at least 100 threads along the line of sight.
- Each thread undergoes a cyclic process of heating to about 1 MK followed by a cooling to about 0.7 MK on a timescale proportional to the loop length.

References

- Bradshaw, S. J., Cargill, P. J.: 2013, The Influence of Numerical Resolution on Coronal Density in Hydrodynamic Models of Impulsive Heating. *Astrophys. J.* **770**, 12.
- Price, D. J., Taroyan, Y.: 2015, Physics of outflows near solar active regions. *Ann. Geophys.* **33**, 25-29, doi:10.5194/angeo-33-25-2015
- Taroyan, Y., Bradshaw, S. J., and Doyle, J. G.: Nanoflare heating of coronal loops: hydrodynamic response and observational consequences, *Astron. Astrophys.*, **446**, 315-325, 2006.
- Taroyan, Y., Erdélyi, R.: 2009, Heating Diagnostics with MHD Waves. *Space Sci. Rev.* **149**, 229-254.