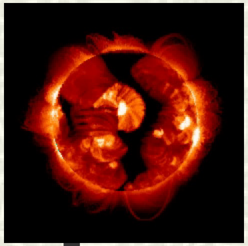

Coronal heating and forecasting the spectral irradiance of the quiescent Sun

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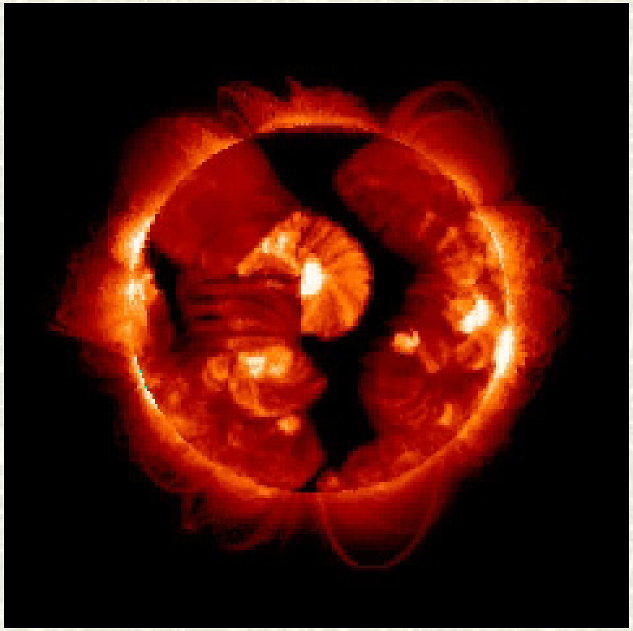
(from a paper submitted to ApJ in Feb. 2004)

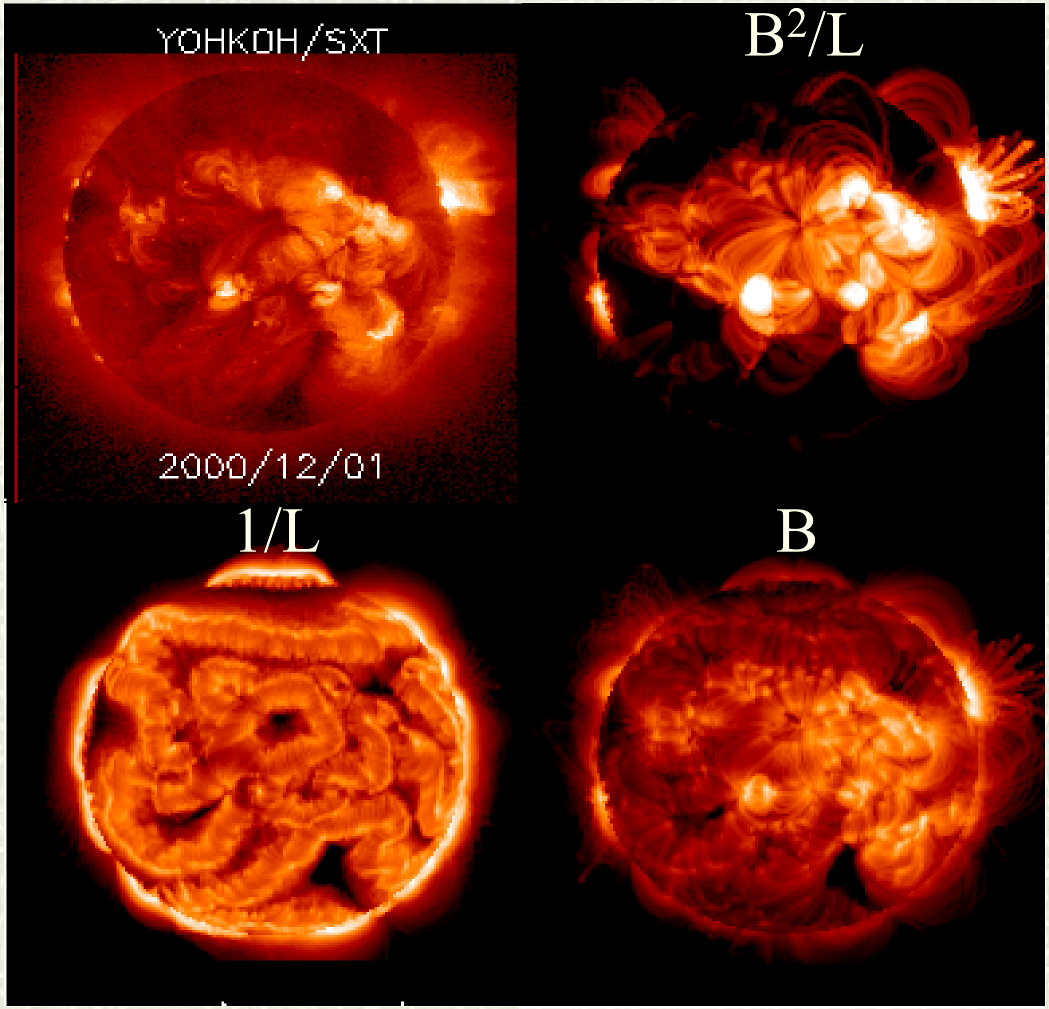
A model solar corona

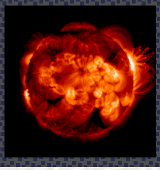


- Model solar corona (not evolving, yet),
- based on observed magnetic field (for 8 Dec. 2000),
- rendered for YOHKOH/SXT Al/Mg filter

Heating and coronal appearance

The appearance of the corona depends sensitively on the properties of coronal heating. These sample images show some of the “worst-fit” cases, for dependences on B^2/L, $1/L$, B.



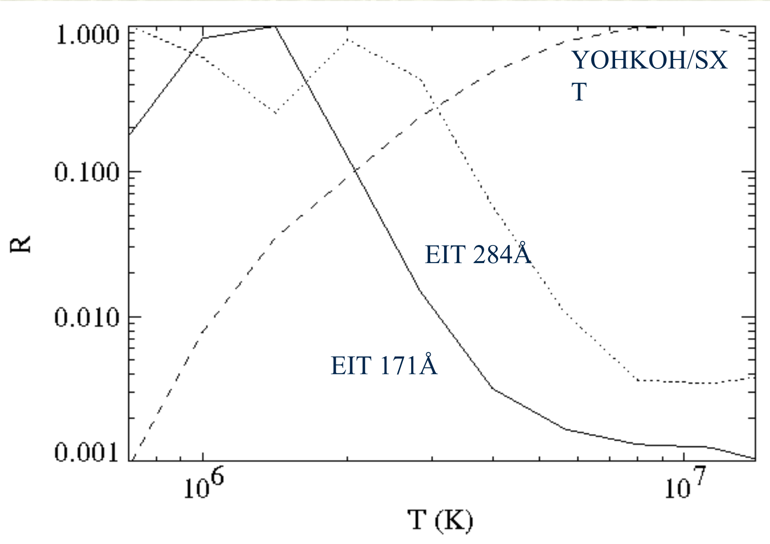


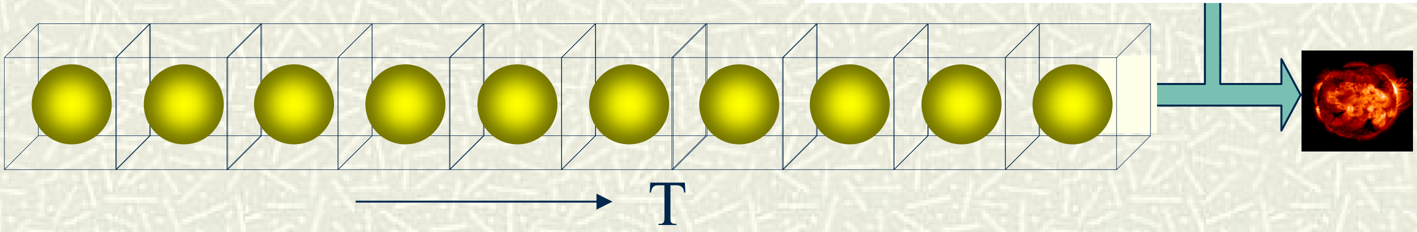
What heats the corona?

- The appearance of the corona depends on how it is heated.
- Visualizing the corona for different heating types can therefore help identify the coronal heating mechanism.
- Coronal heating power for loops of ~100,000 km or less: $F_H = 4 \times 10^{14}\, B^{1.0\pm0.2}/L^{1.0 \pm 0.4}$ (ergs/cm^2/s), essentially everywhere. Likely stronger heating in longest loops.
- “Anchor” for simulations to determine constant of prop.: a typical plage loop must have an apex temperature of 3 MK.
- Heating mechanism is, most likely, reconnection at braiding-induced discontinuities, proceeding proportional to the Alfvén speed (as proposed by Parker)

Visualizing the corona

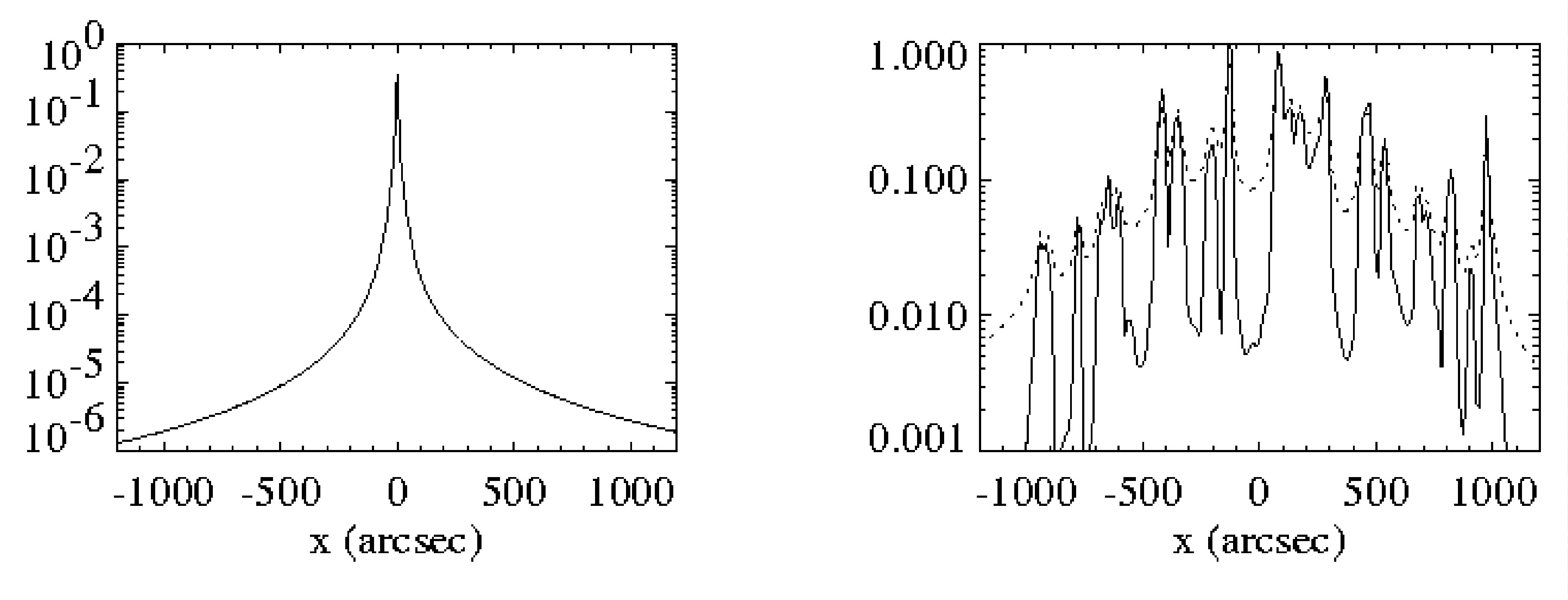
- Model steps:
  - model the surface field by assimilating magnetograms into a model (http://www.lmsal.com/forecast),
  - trace field lines through volume,
  - determine (trial) heating rates,
  - compute loop atmospheres,
  - differentiate by temperature,
  - fold with thermal responses,
  - convolve with psf.





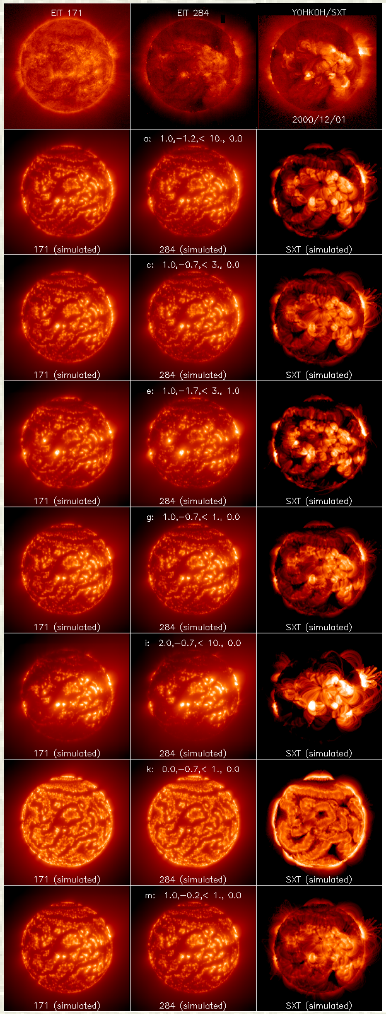
… as we would observe it

- EIT psf (left)
- and the effect on contrast in 171A image (right)



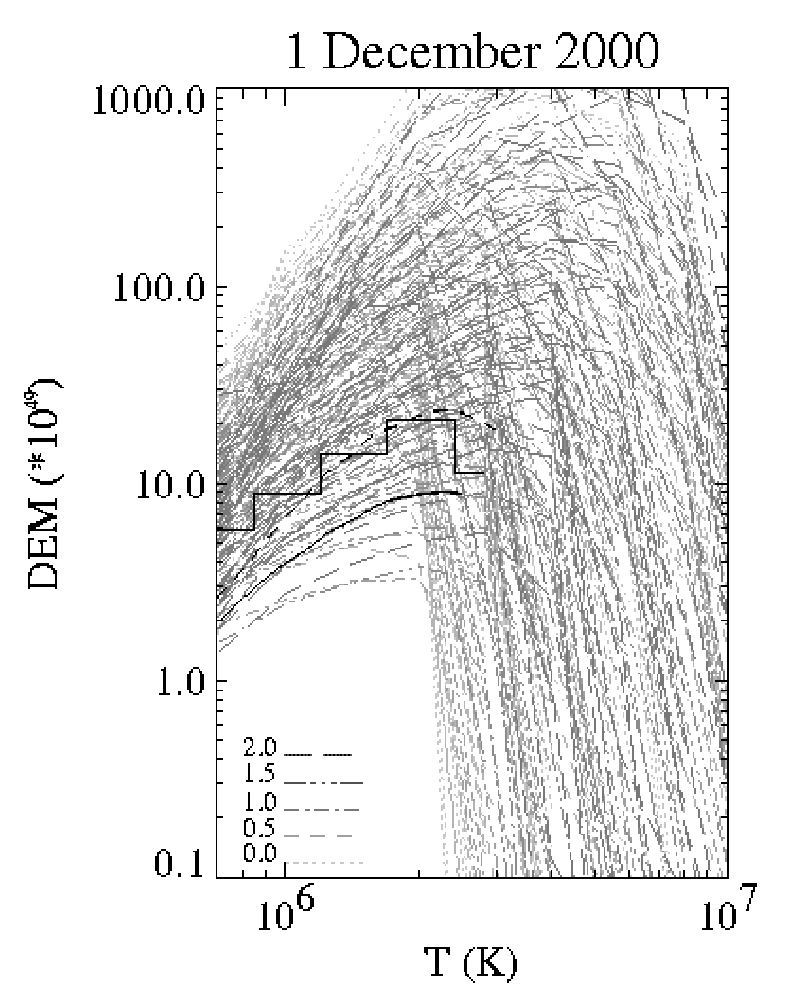
Identifying the dependence of coronal heating on field properties

- Explored 225 different parameterizations, for two different dates, using 100,000 "half loops" based on a PFSS model, assuming quasi-static atmospheres.
- The best fit yields highest cross-correlation for linear fit, best visual agreement, *and* good match to the overall emission measure distribution.

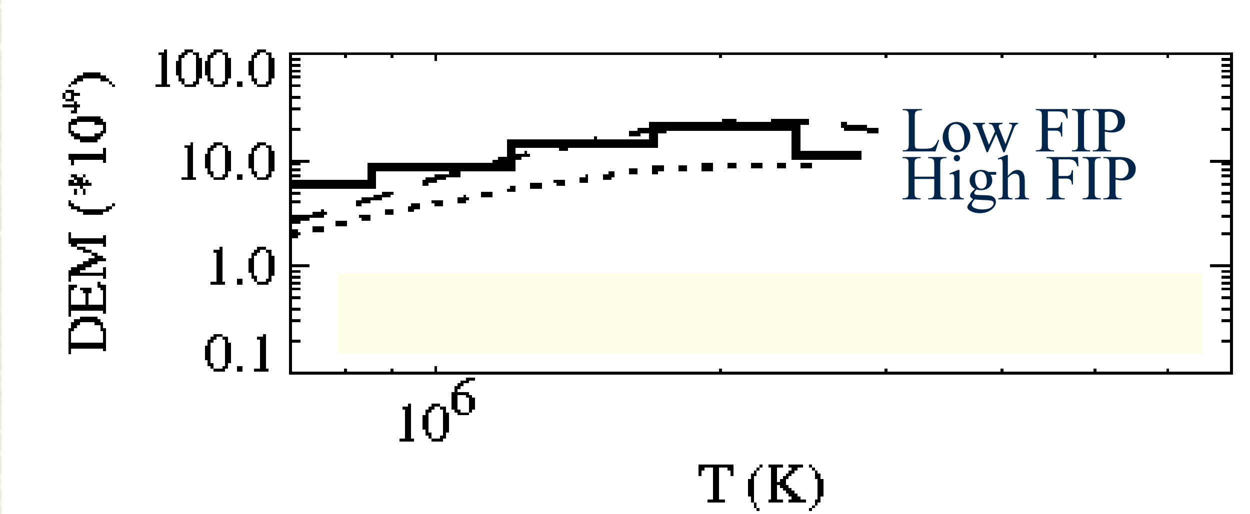


Heating and EM(T)

- The overall emission measure also is sensitive to the heating properties.
- Most models are too hot or too faint.

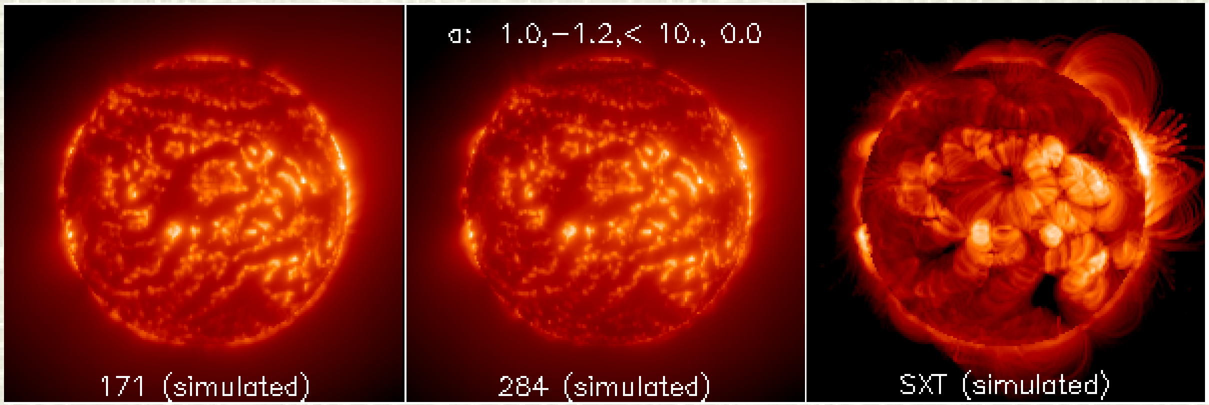


EM(T) and irradiance

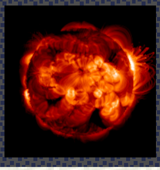


- EM(T) is reproduced quite well, although there is too much plasma for temperatures below 1 MK.

A closer look at the best fit



- Better match for X-ray image if heating for loops longer than ~50,000 km is increased, e.g., to a minimum power density matching that going into coronal holes.
- For 1-2 MK plasma, the images show too much contrast, lack the "cool loops" seen in TRACE data, and have an excess DEM(T) by a factor of ~2 below 1 MK.

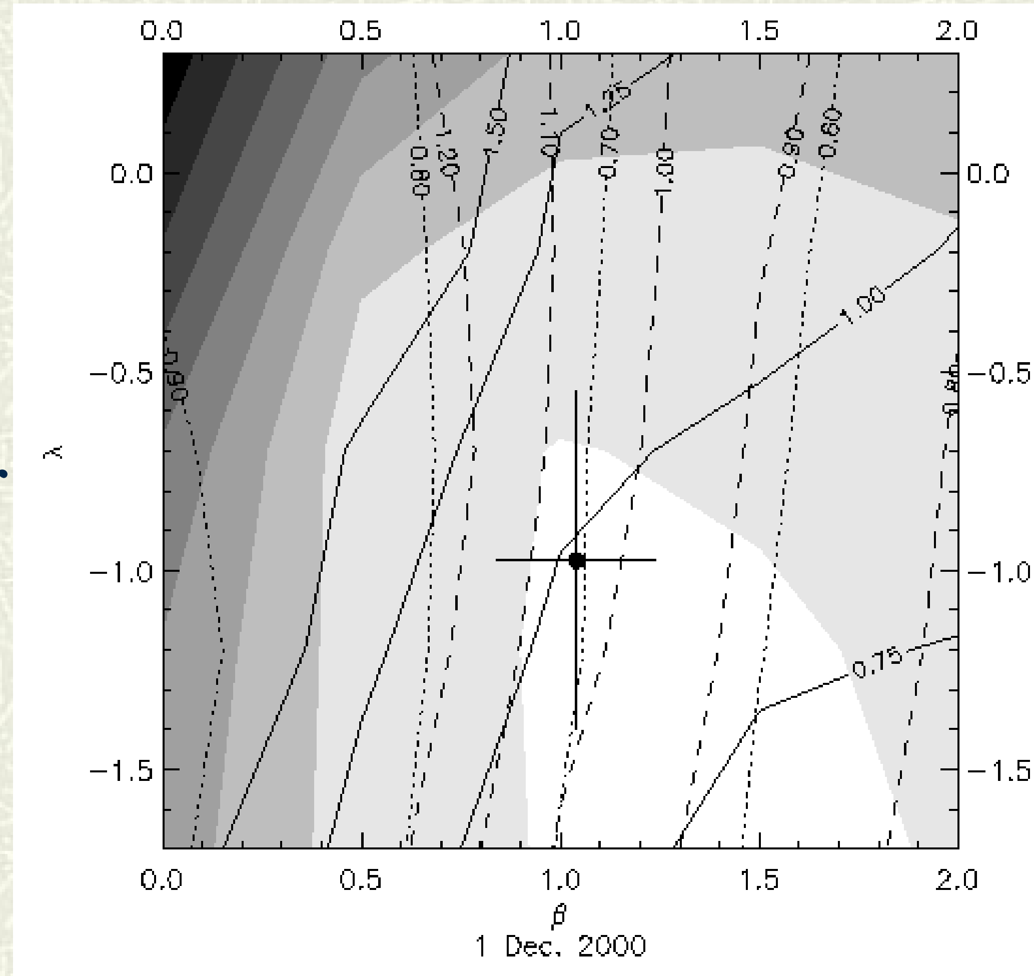


Conclusions

- The EUV and X-ray irradiance of the quiescent Sun can be modeled (and forecast) quite well by forward modeling based on magnetograms.
- Future improvements:
  - Tests of other heating parameterizations,
  - (Near) TR emissions,
  - Effects of abundances,
  - Asymmetric, expanding, dynamic loops,
  - Long-loop heating,
  - Improve calibrations.

Exploring parameter space

- A good fit should have high cross-correlation (brighter area) and linear fits for X-ray, 284, and 171 (contours: solid, dashed, dotted)



Best-fit and models

- For: $F_H \propto B^{\lambda} / L^{\beta}$
- Best-fit (●) for model '4', the Parker braiding model!