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Line identifications with EIS and CHIANTI

Peter Young[1,2] & Enrico Landi[1,3]

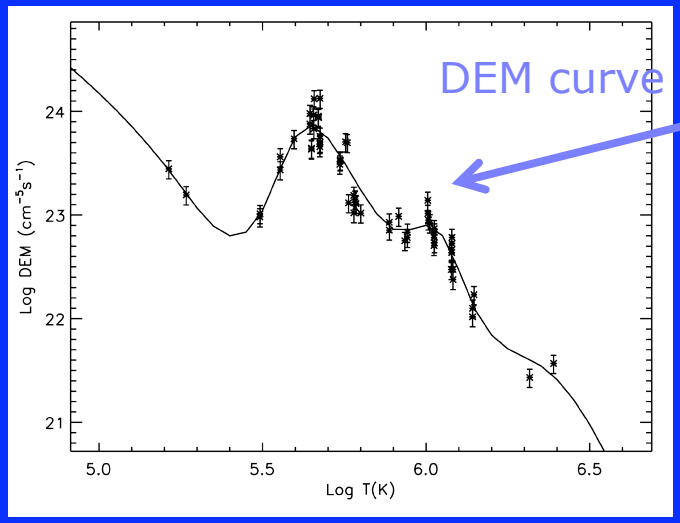
[1]Naval Research Laboratory

[2]George Mason University

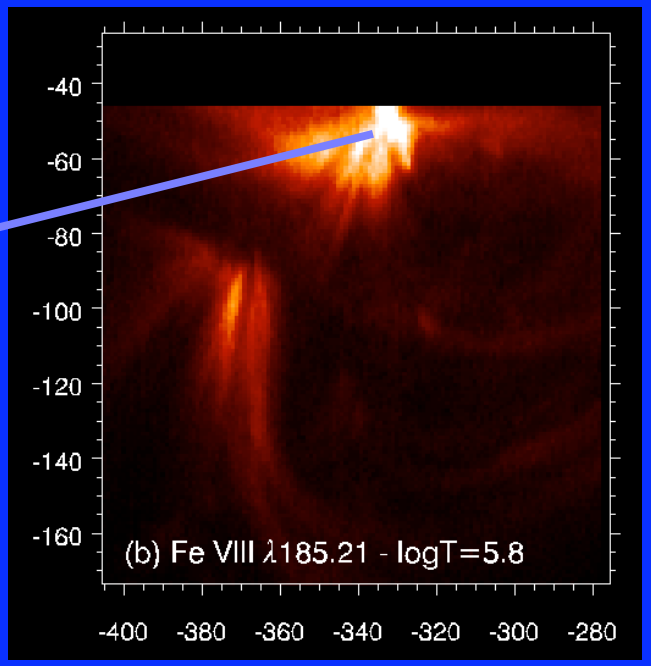
[3]Artep Inc.

Summary

- A full CCD spectrum obtained in loop footpoint regions shows strongly enhanced lines formed at log T = 5.5-5.9
- Excellent opportunity to study Fe VII, VIII & IX
- Many new lines found and identified
- Young (2009, ApJL); Young & Landi (2009, in preparation)



DEM curve



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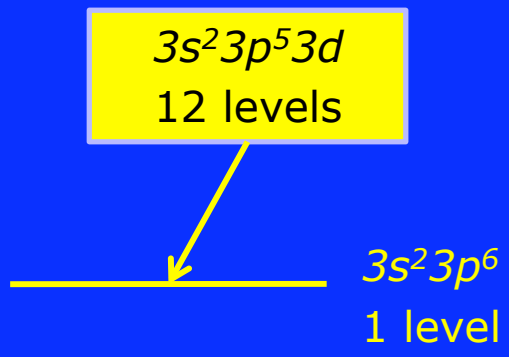
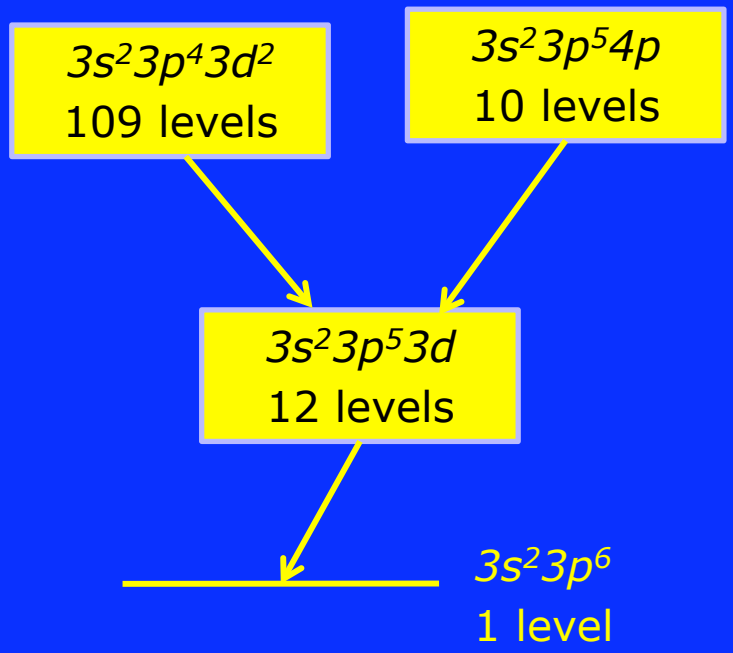
Fe IX



Pre-2002 Fe IX atomic model



Current Fe IX atomic model
(Storey et al. 2002)

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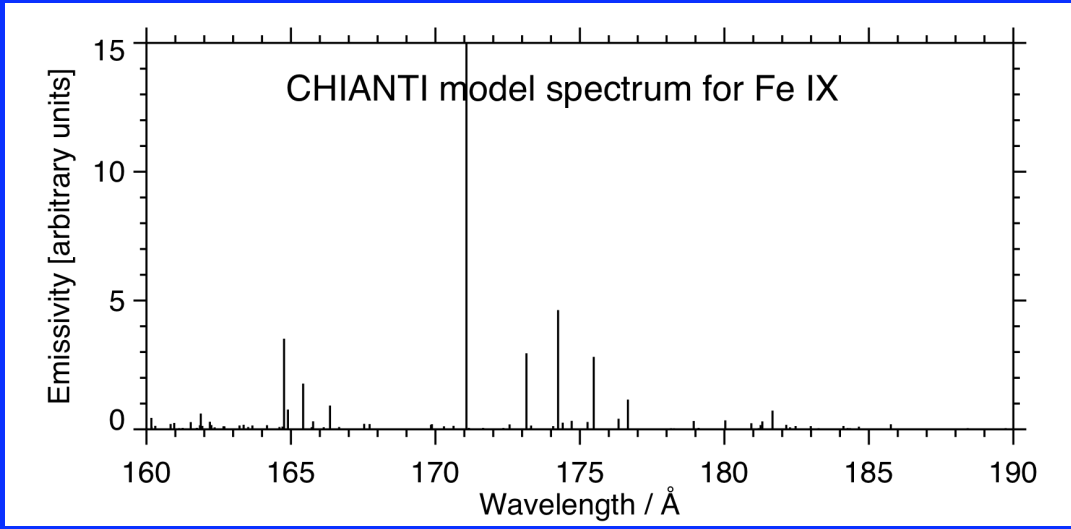
Predicted CHIANTI spectrum



Unidentified lines account for 25 % of Fe IX emission between 160 and 200 Å

- Important for modeling 171 and 195 channels of EIT, TRACE, EUVI and AIA

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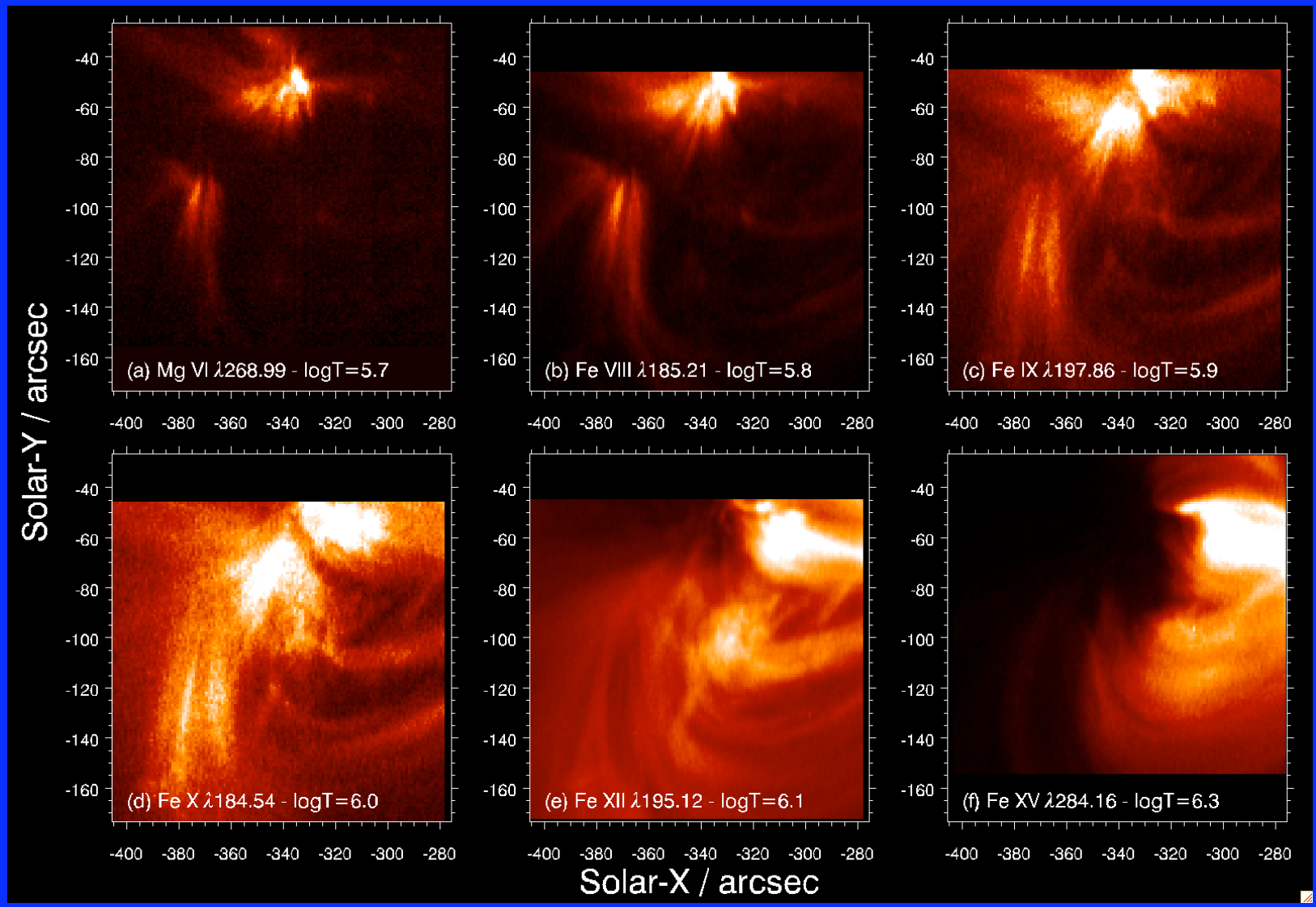
Images from AR 10942, 21-Feb-2007



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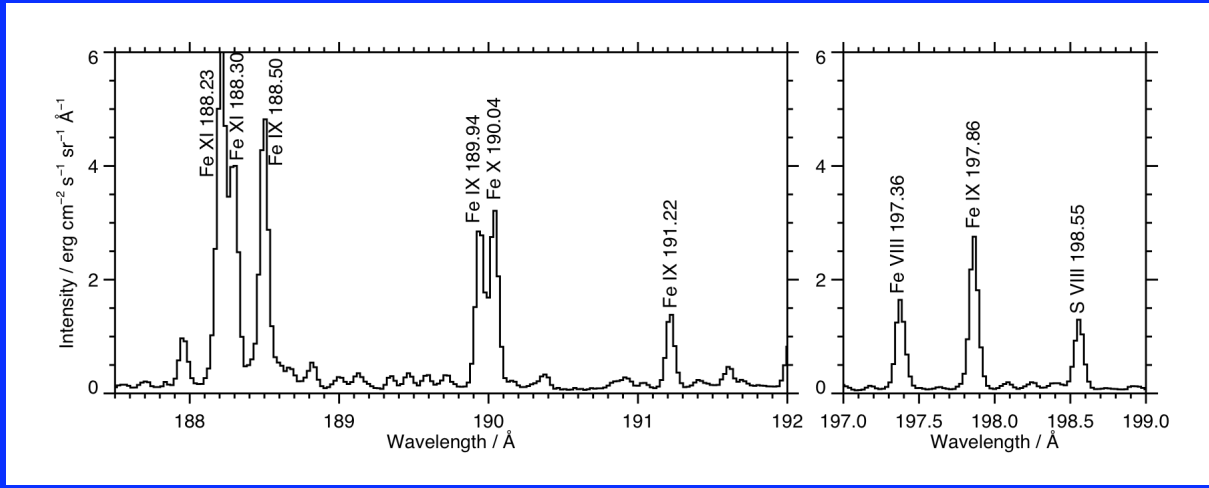
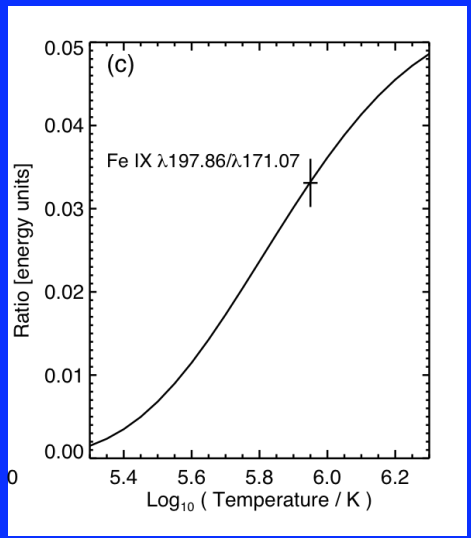
EIS Fe IX lines & diagnostic



- Lines can be observed in most solar conditions
- λ197.86/λ171.07 is excellent temperature diagnostic
- λ197.86 is recommended for EIS studies
- λ188.50 often observed in Fe XI 188.23 window
- Young (2009, ApJL)



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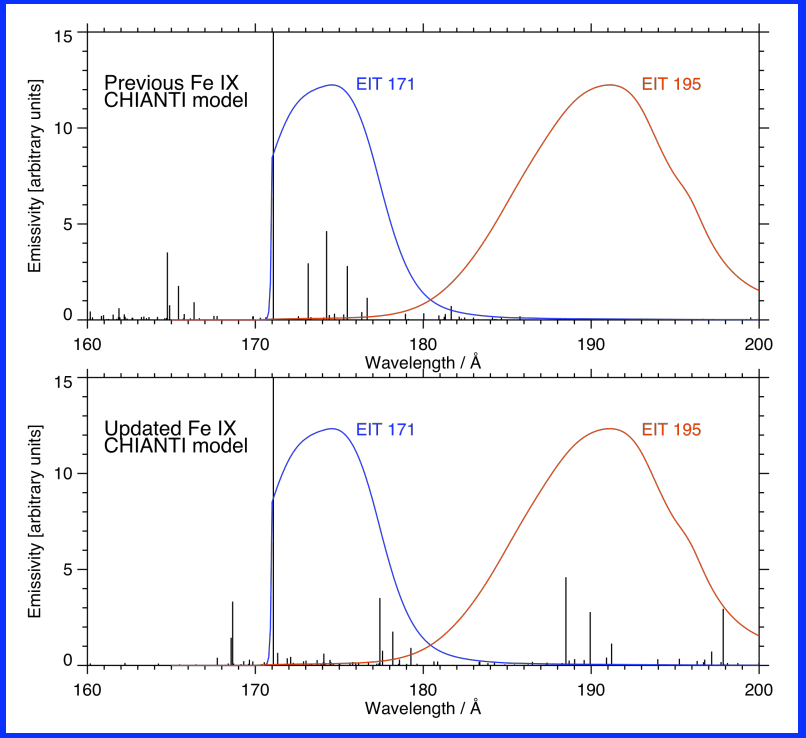
Fe IX and EIT wavebands

- None of the 109 $3s^2 3p^4 3d^2$ levels previously had experimental energies
- Using the three new lines to adjust energies for the entire configuration shifts predicted emission lines by several Å
- Fe IX contributes 9 times more emission to EIT 195 band than previous spectral model
  - affects EIT 195/171 temperature diagnostic



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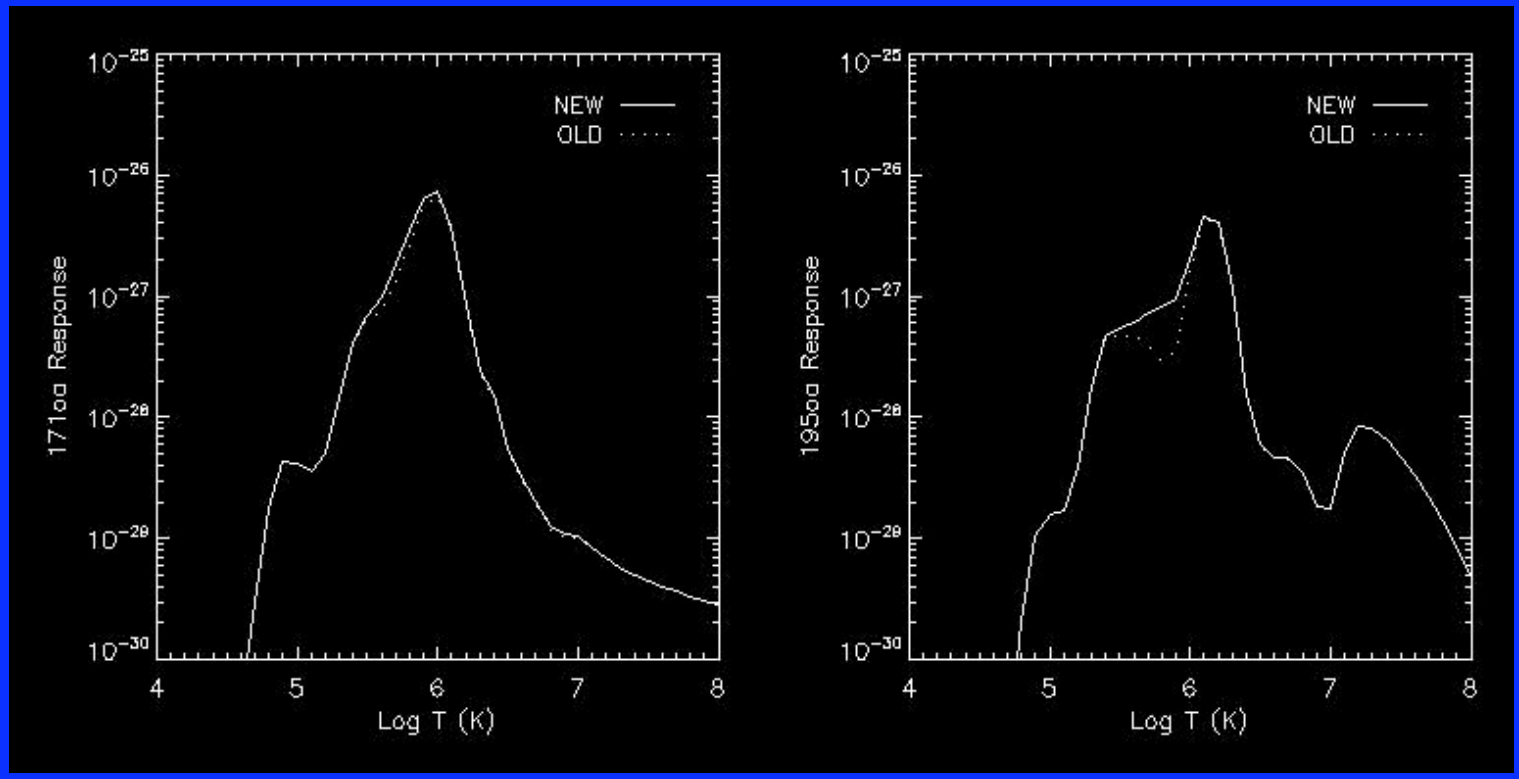
Fe IX and TRACE response



'OLD' – CHIANTI v5.2.1

'NEW' – CHIANTI v5.2.1 + revised Fe IX model

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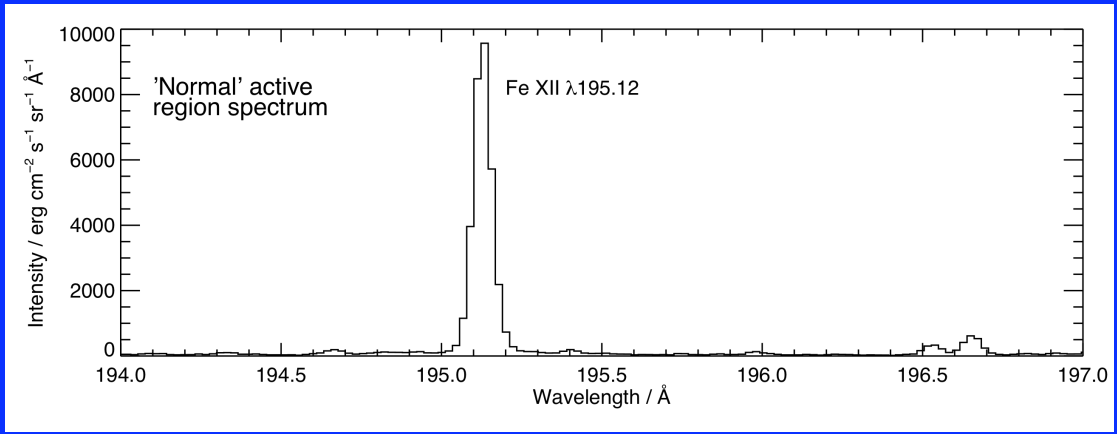
Fe VII in loop footpoints

- Fe VII lines are normally weak, but loop footpoints show strongly enhanced lines
- Ideal 'laboratory' for investigating Fe VII



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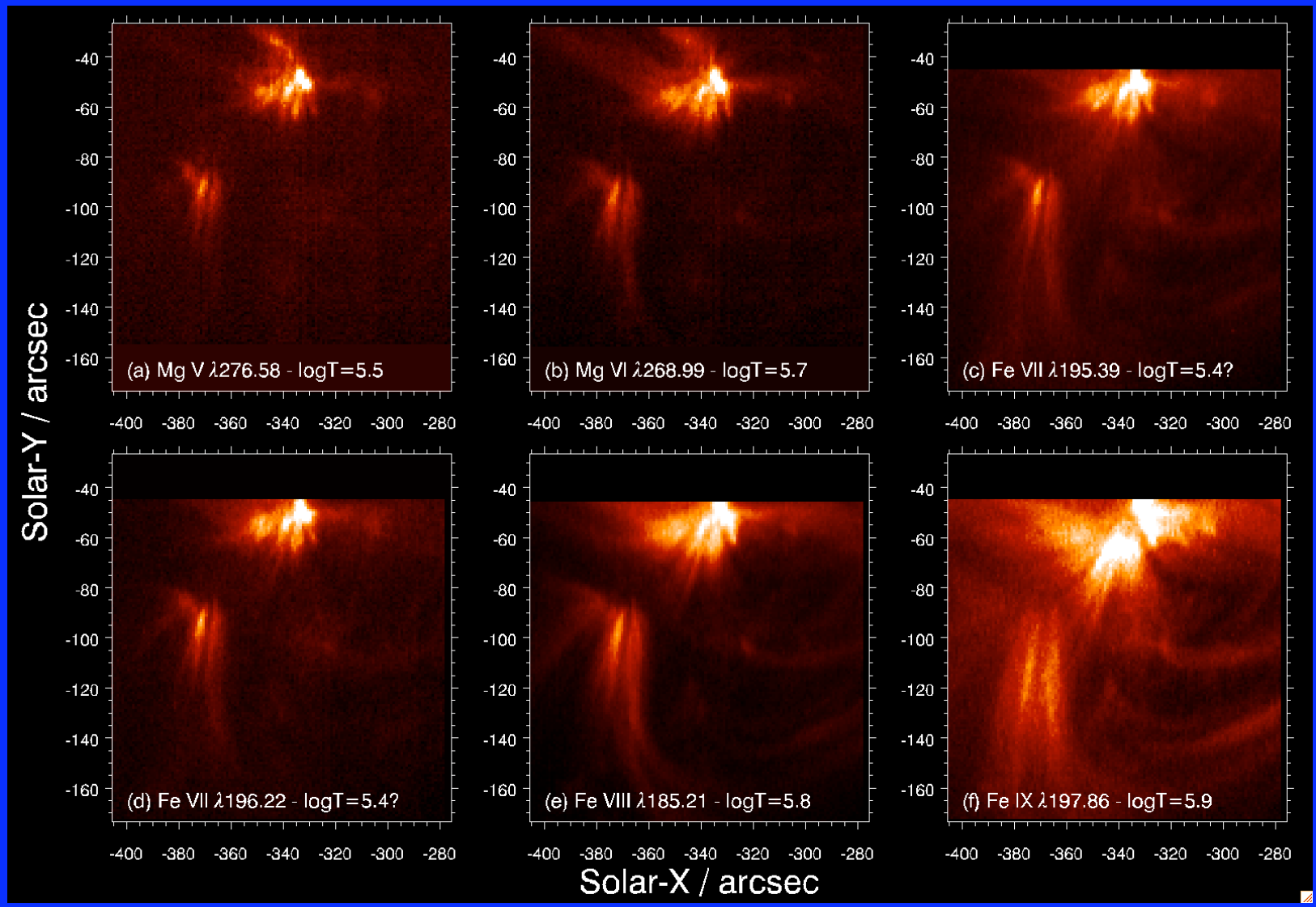
Images of AR 10942, 21-Feb-2007



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Fe VII

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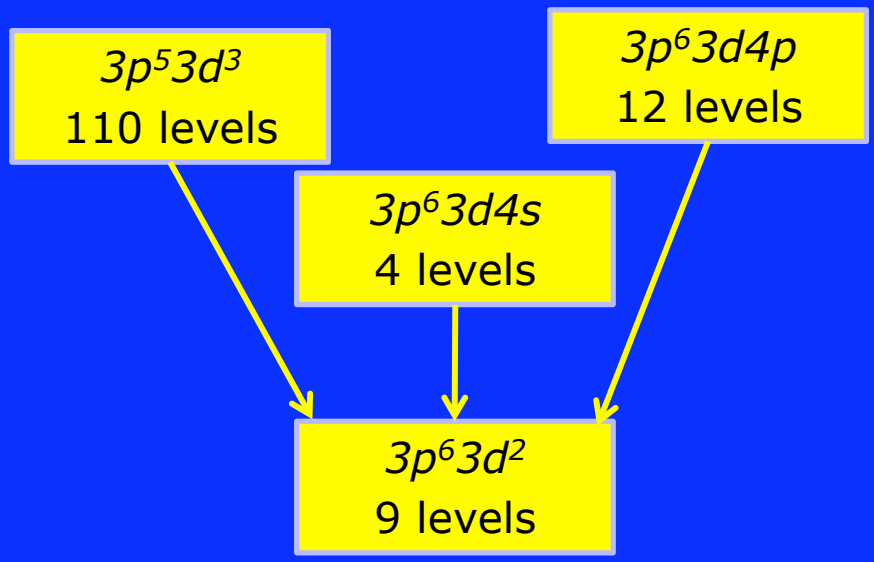
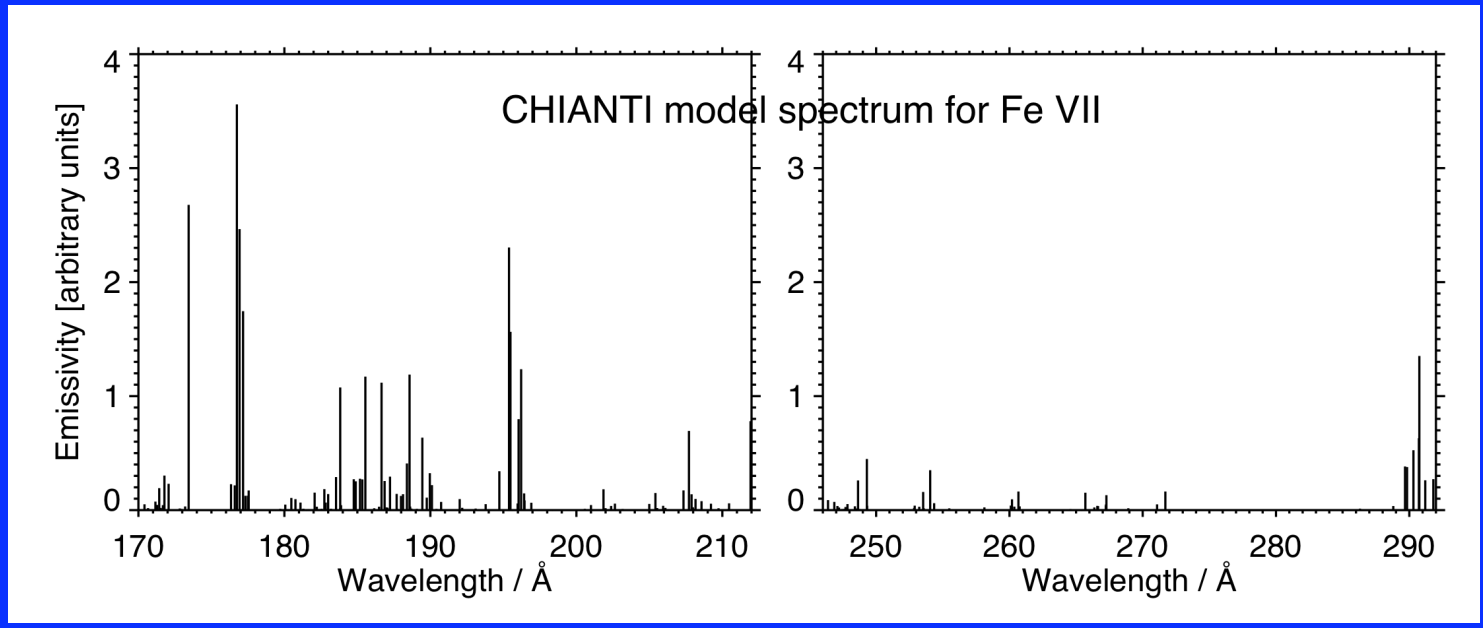
$3p^6 3d^2$
9 levels

Current Fe VII atomic model
(no lines in EUV)



New Fe VII atomic model
(Witthoeft & Badnell 2008)

Predicted CHIANTI Fe VII spectrum



- 11 new line identifications made from EIS spectra (mainly in LW band)
- 16 new or revised energy levels

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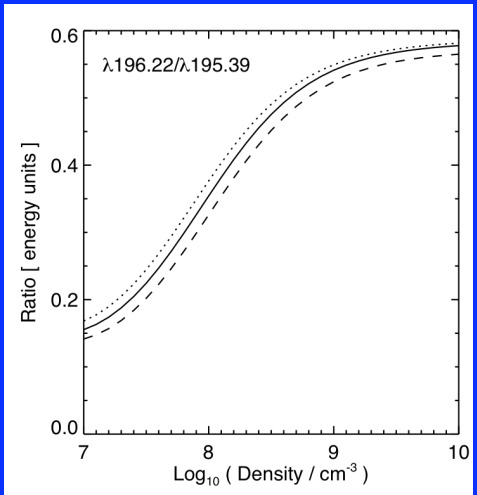
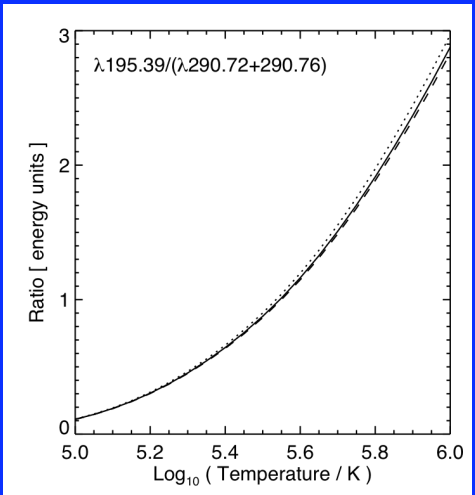
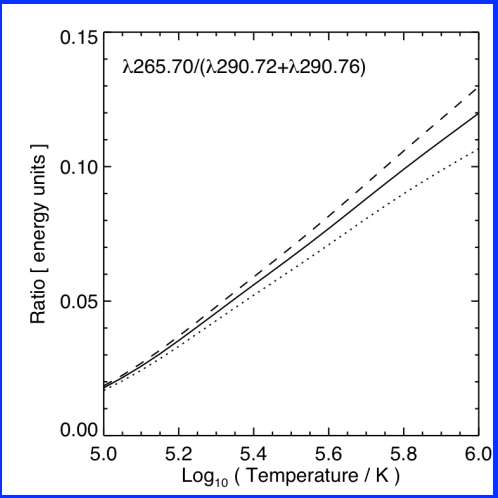
Fe VII diagnostics

- Line ratios show no significant density sensitivity above 10^9 cm^{-3}
- A number of ratios show strong temperature sensitivity







- Recommended lines for EIS studies: λ195.39, λ196.22

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Fe VII problems

- Studying ratios that are insensitive to plasma conditions has revealed many prob
- A number o
- Coupled wi the ion should not
- High resolu g problems and confirm

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Table 5: Fe VII insensitive ratios.

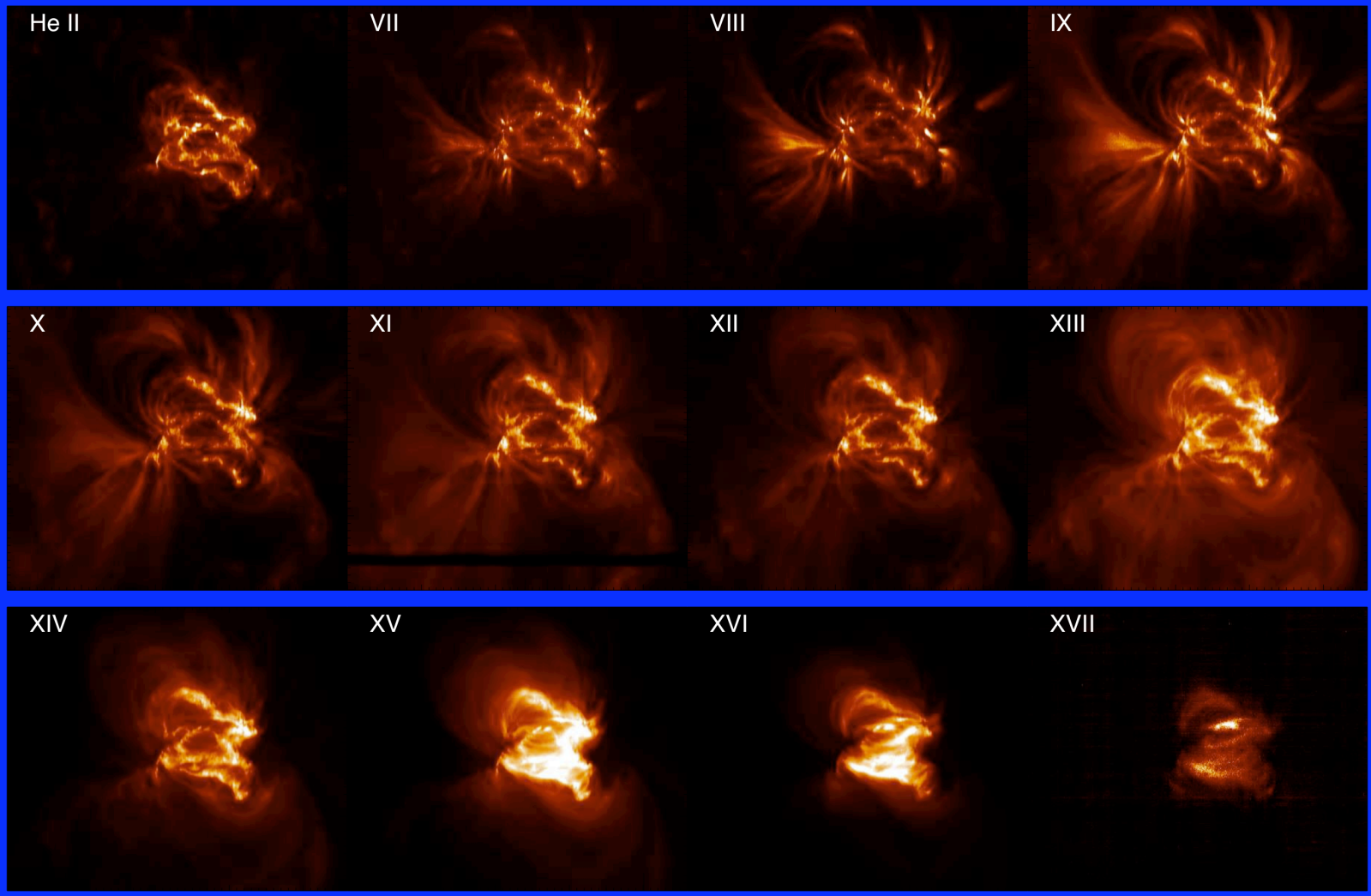
Term[a]	Ratio	Theory	Observation[b]
$3p^5 3d^3(^4P)\ ^3P$	$\lambda184.89/\lambda183.83$	0.238 ± 0.007	0.222 ± 0.034
	$\lambda183.83/\lambda195.39$	0.437 ± 0.065	0.404 ± 0.025
$3p^5 3d^3(^2G)\ ^1F$	$\lambda185.55/\lambda195.39$	0.478 ± 0.078	0.294 ± 0.018 ◀
$3p^5 3d^3(\mathrm{b}^2D)\ ^1D$	$\lambda186.66/\lambda195.39$	0.458 ± 0.069	0.195 ± 0.032 ◀
$3p^5 3d^3(^2F)\ ^3D$	$\lambda189.45/\lambda188.58$	0.542 ± 0.028	0.935 ± 0.129 ◀
	$\lambda189.45/\lambda195.39$	0.265 ± 0.024	0.236 ± 0.010 ◁
	$\lambda188.58/\lambda195.39$	0.489 ± 0.068	0.253 ± 0.034 ◀
$3p^5 3d^3(^2H)\ ^3G$	$\lambda195.49/\lambda195.39$	0.698 ± 0.057	0.520 ± 0.013 ◀
	$\lambda196.05/\lambda195.39$	0.359 ± 0.026	0.358 ± 0.013
$3p^5 3d^3(\mathrm{a}^2D)\ ^3F$	$\lambda196.42/\lambda195.39$	0.067 ± 0.015	0.118 ± 0.006 ◀
$3p^5 3d^3(^2F)\ ^1G$	$\lambda201.86/\lambda195.39$	0.085 ± 0.017	0.212 ± 0.013 ◀
$3p^5 3d^3(^2F)\ ^3G$	$\lambda207.71/\lambda195.39$	0.319 ± 0.034	0.397 ± 0.036 ◁
$3p^5 3d^3(^4F)\ ^5F$	$\lambda248.64/\lambda249.30$	0.593 ± 0.06	0.493 ± 0.067
	$\lambda260.68/\lambda249.30$	0.373 ± 0.032	0.281 ± 0.035 ◁
$3p^5 3d^3(^4F)\ ^5D$	$\lambda253.53/\lambda254.06$	0.457 ± 0.016	0.385 ± 0.065
	$\lambda254.06/\lambda249.30$	0.800 ± 0.105	0.702 ± 0.085
	$(\lambda267.23+\lambda267.25^c+\lambda267.27)/\lambda249.30$	0.516 ± 0.050	0.483 ± 0.046
	$(\lambda267.23+\lambda267.25^c+\lambda267.27)/\lambda254.06$	0.645 ± 0.021	0.688 ± 0.075
$3p^5 3d^3(^4P)\ ^5S$	$\lambda271.70/\lambda249.30$	0.375 ± 0.053	0.351 ± 0.036
$3p^6 3d4s\ ^3D$	$\lambda289.68/(\lambda290.72+\lambda290.76)$	0.193 ± 0.001	0.213 ± 0.032
	$\lambda289.83/(\lambda290.72+\lambda290.76)$	0.191 ± 0.002	0.205 ± 0.029
	$\lambda290.31/(\lambda290.72+\lambda290.76)$	0.267 ± 0.005	0.389 ± 0.041 ◀

[a] Ratios are grouped according to the spectroscopic term of the upper emitting level. Ratios are formed either between lines emitted from the same term, or one of these lines relative to a reference line (λ195.39 for the EIS SW band, and λ249.30 for the LW band).

[b] A ◁ symbol indicates a $> 1\sigma$ discrepancy between theory and observation, ◀ indicates a $> 2\sigma$ discrepancy.

[c] A theoretical wavelength.

Consecutive Fe VII to Fe XVII images



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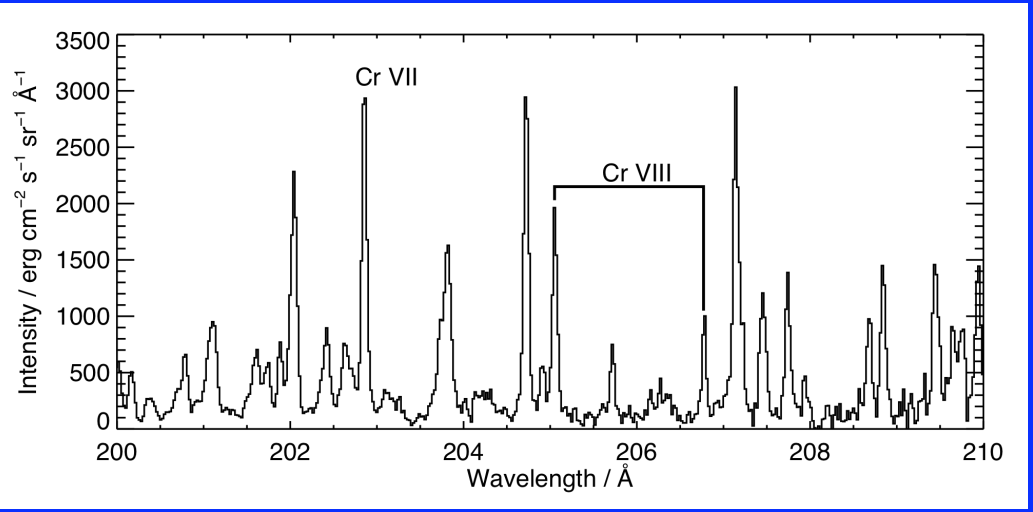
Chromium lines

- Chromium (Z=24) is 68 times less abundant than iron
- The large emission measure at log T = 5.5-5.8 strongly enhances lines of Cr VII and Cr VIII
- Lines have been identified in solar spectrum for the first time



- New atomic data have been calculated for these ions for inclusion in CHIANTI (Landi & Young 2009, in preparation)

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Summary

- EIS is important for testing atomic data and making new line identifications
- Since EIS covers wavelength bands observed by imaging instruments (171, 195, 284), atomic data improvements directly benefit these instruments

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