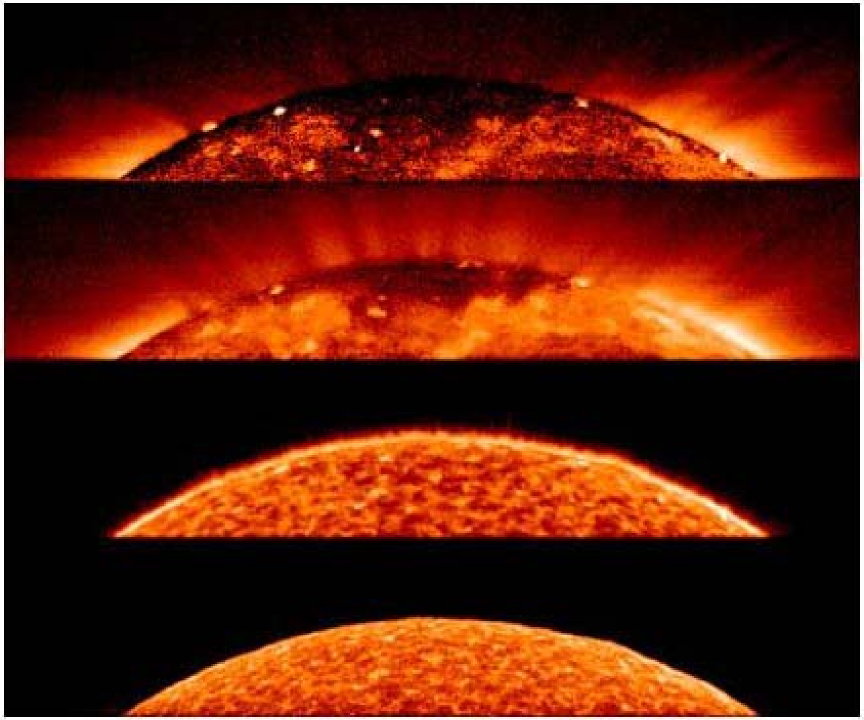
Resonant scattering in the solar transition region. The C IV 1548Å, 1550Å lines



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C IV ion and spectral lines 1548A, 1550A

Oscillator strength of 1548 twice the 1550 one.

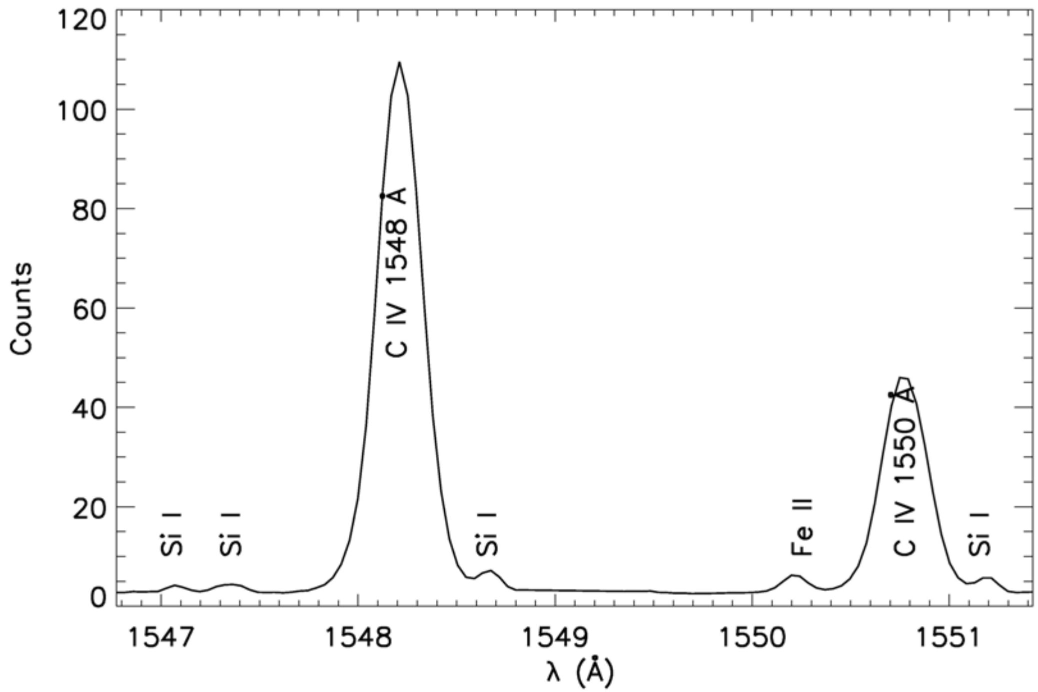
$I_{1548} \sim n_i\, n_e\, C_{1548}(T)\, L$

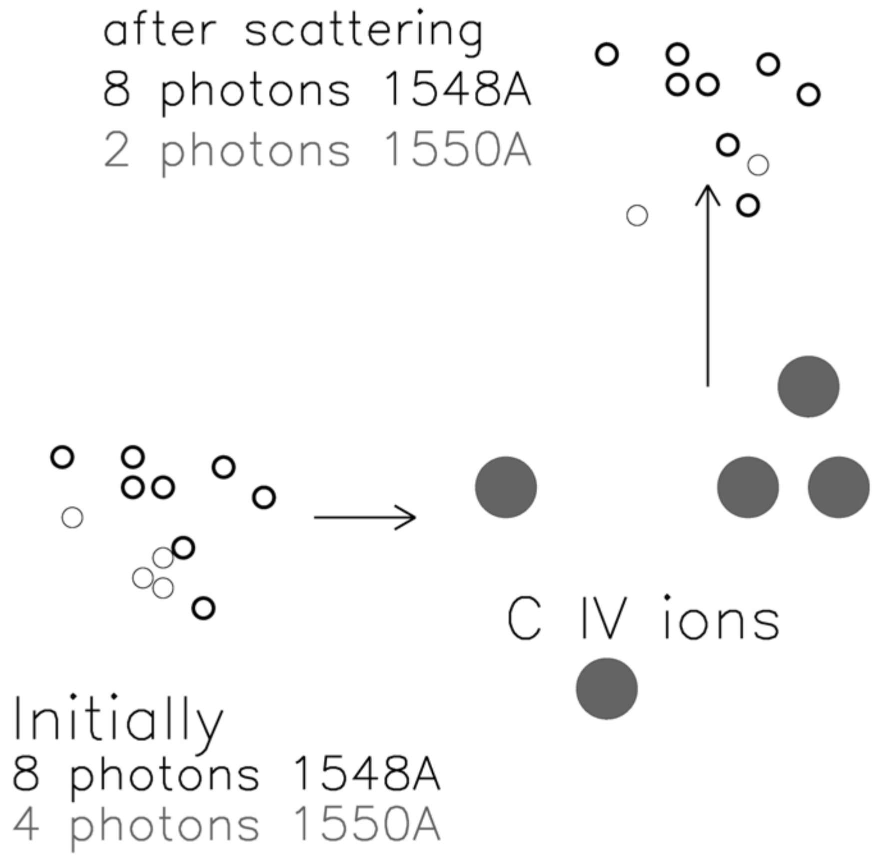
$I_{1550} \sim n_i\, n_e\, C_{1550}(T)\, L$

$C_{1548}(T)=2\, C_{1550}(T)$

$B_{1548} = 2\, B_{1550}$

=> $\mathbf{I_{1548}/I_{1550} = 2}$



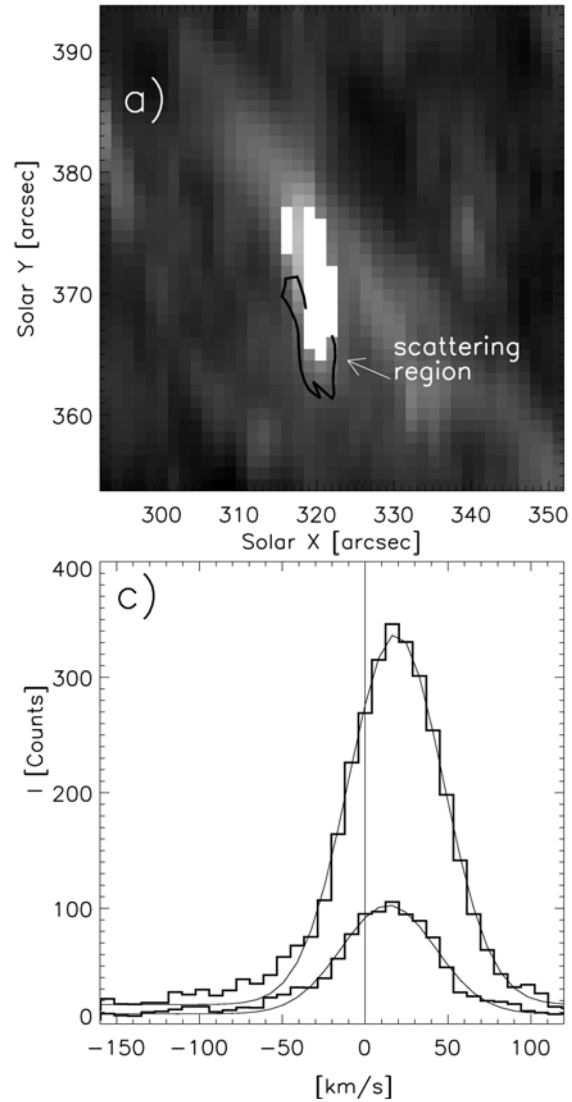


Initial lines ratio: $\mathbf{I_{1548}/I_{1550} = 2}$

Scattered ratio : $\mathbf{I_{1548}/I_{1550} = 4}$

SUMER raster
Of microflare with
Resonant scattering
In C IV 1548A

NOAA 8541   15 May 1999



Resonant scattering due to

High Microflare Incident intensity

Low electron density on Solar pore

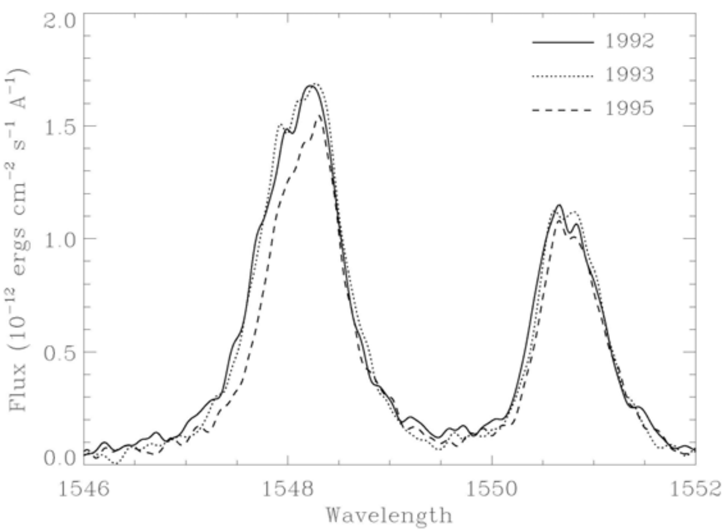
Electron density > 2 × 10^8 cm^{-3}

Radiative/Collision term >0.1

Gontikakis, Winebarger, Patsourakos, 2013, A&A
Hellenic National Network for Space Weather Reseach

Spectral Asymmetries, Doppler Shifts Variation for 1548, 1550

An effect due to Scattering ?



β-Draconis HST (Wood et al 1997)

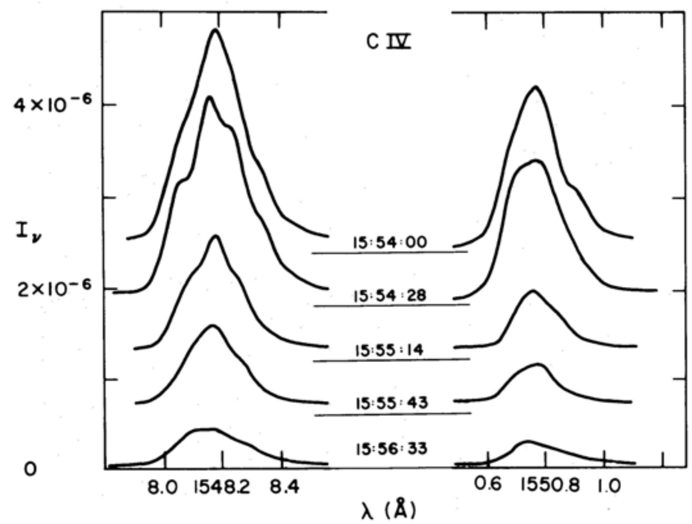
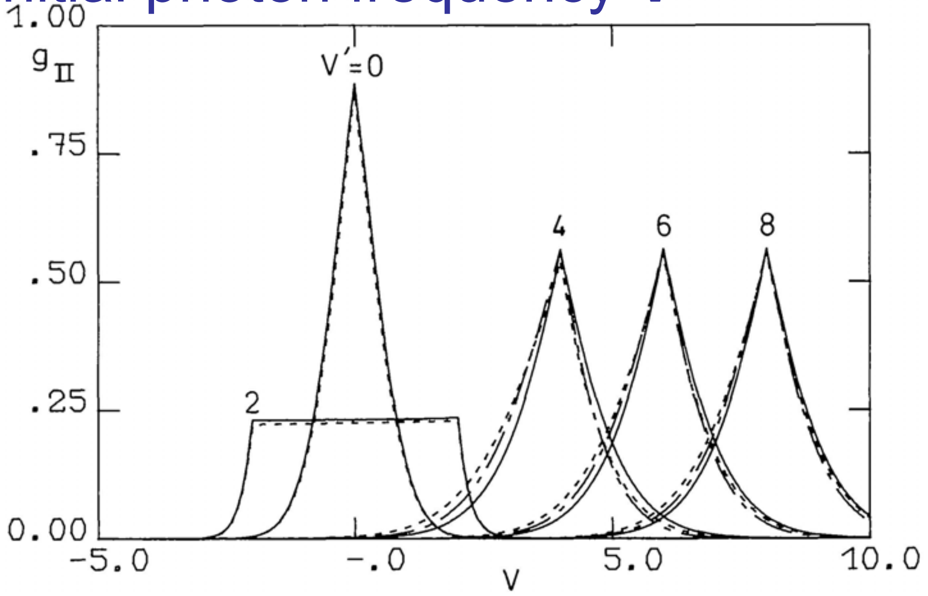


FIG. 1c

Flare Skylab: Lites & Cook 1979

Coherent scattering:
The scattered photon frequency **V** is correlated to Initial photon frequency **V’**



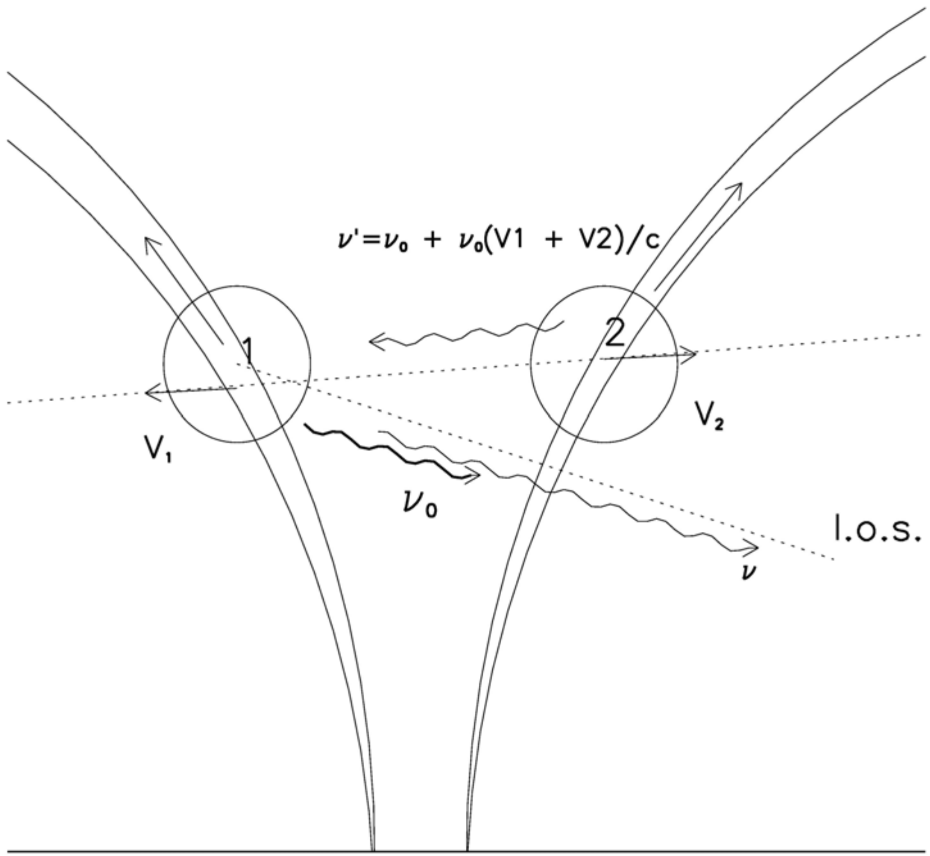
Gouttebroze (1986)

V’<2   scattering from atoms with small speed
V’ >2 scattering from atoms with speeds vel~c V’/v0

$$\nu_D = \frac{\nu_0}{c}\sqrt{\frac{2kT}{m_c}}$$

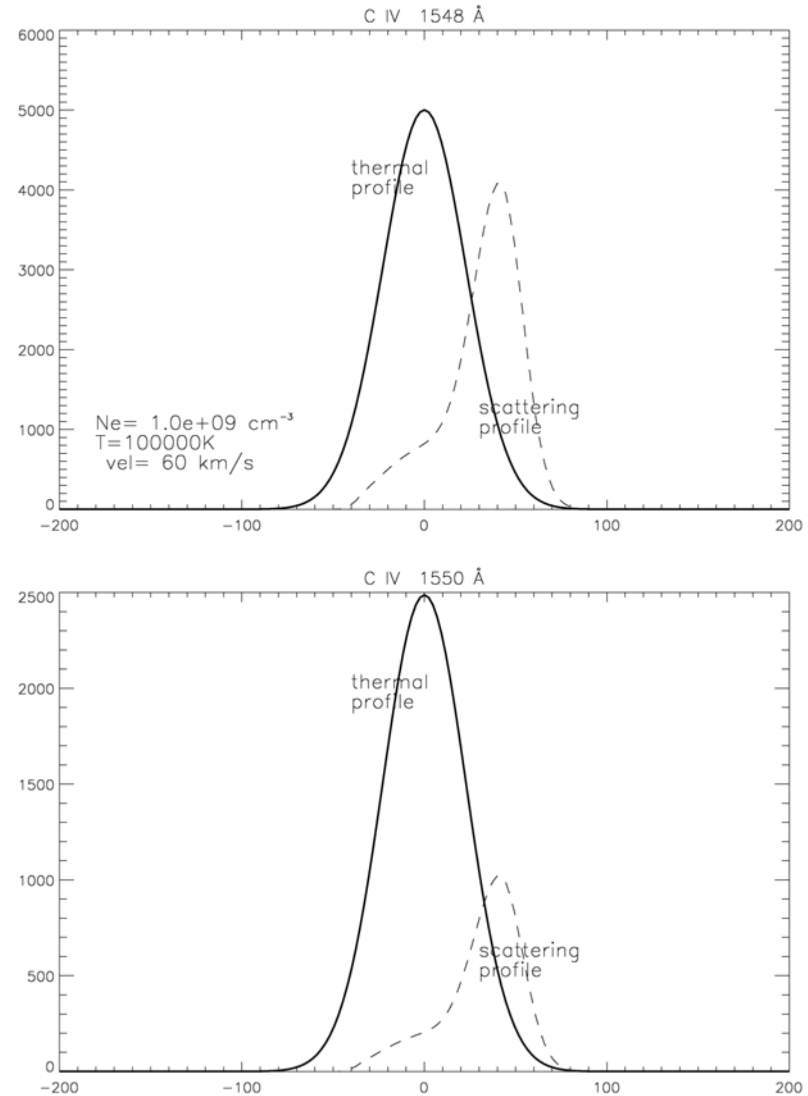
Cram & Vardavas 1978

Example : coherent scattering produces different shapes for 1548A and 1550A



photosphere

The thermal and scattering spectral components have the same shape for both lines but They are have different ratios.



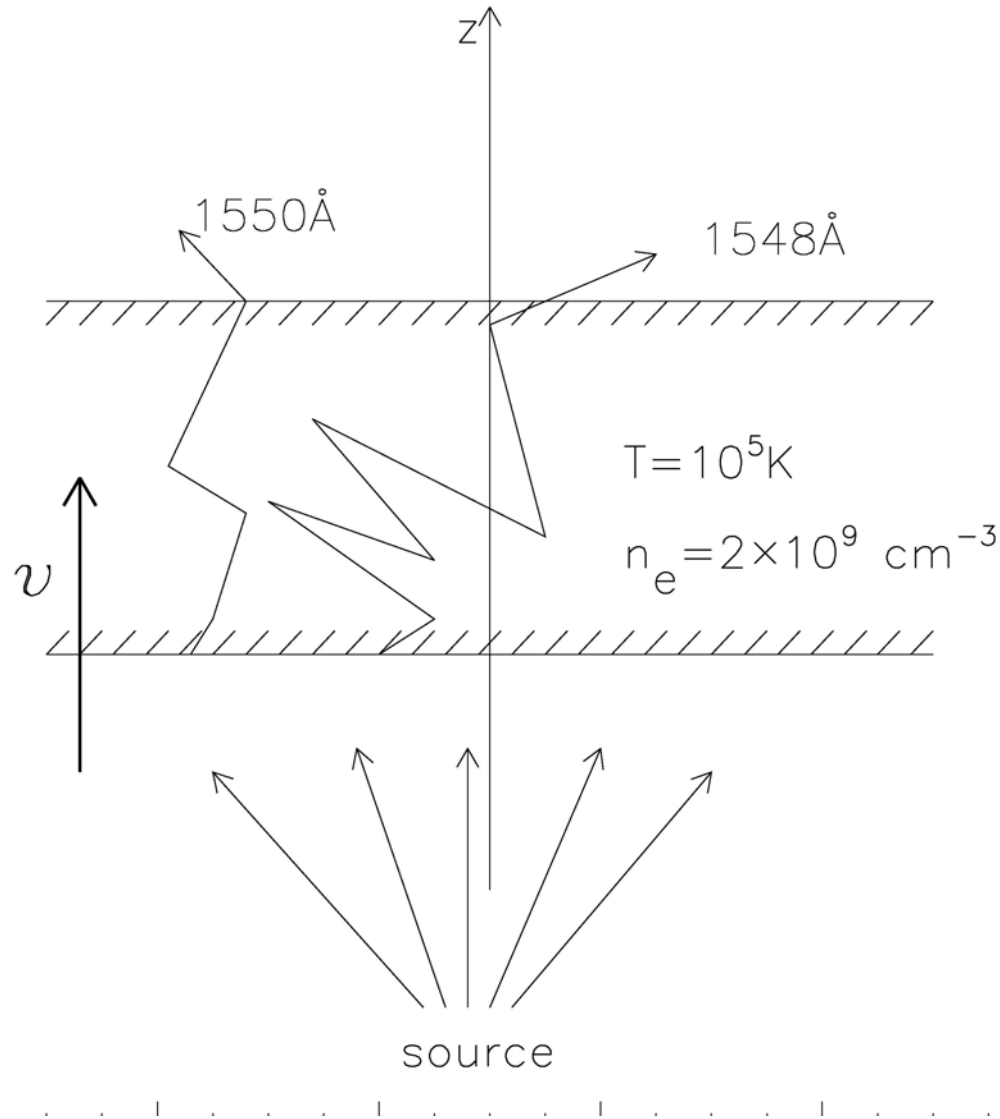
Modeling of radiative transfer Using Monte-Carlo method..

Incident photons $\mathbf{u_0}$ selected from Gaussian distribution.

At each scatter the photon frequency **u** changes

according to $\mathbf{g_{II}}\,\mathbf{(u,u')}$

Whitney (2011), B.A.S.I.
Wood, Withney, et al 2001



Monte-Carlo
C IV profiles simulation

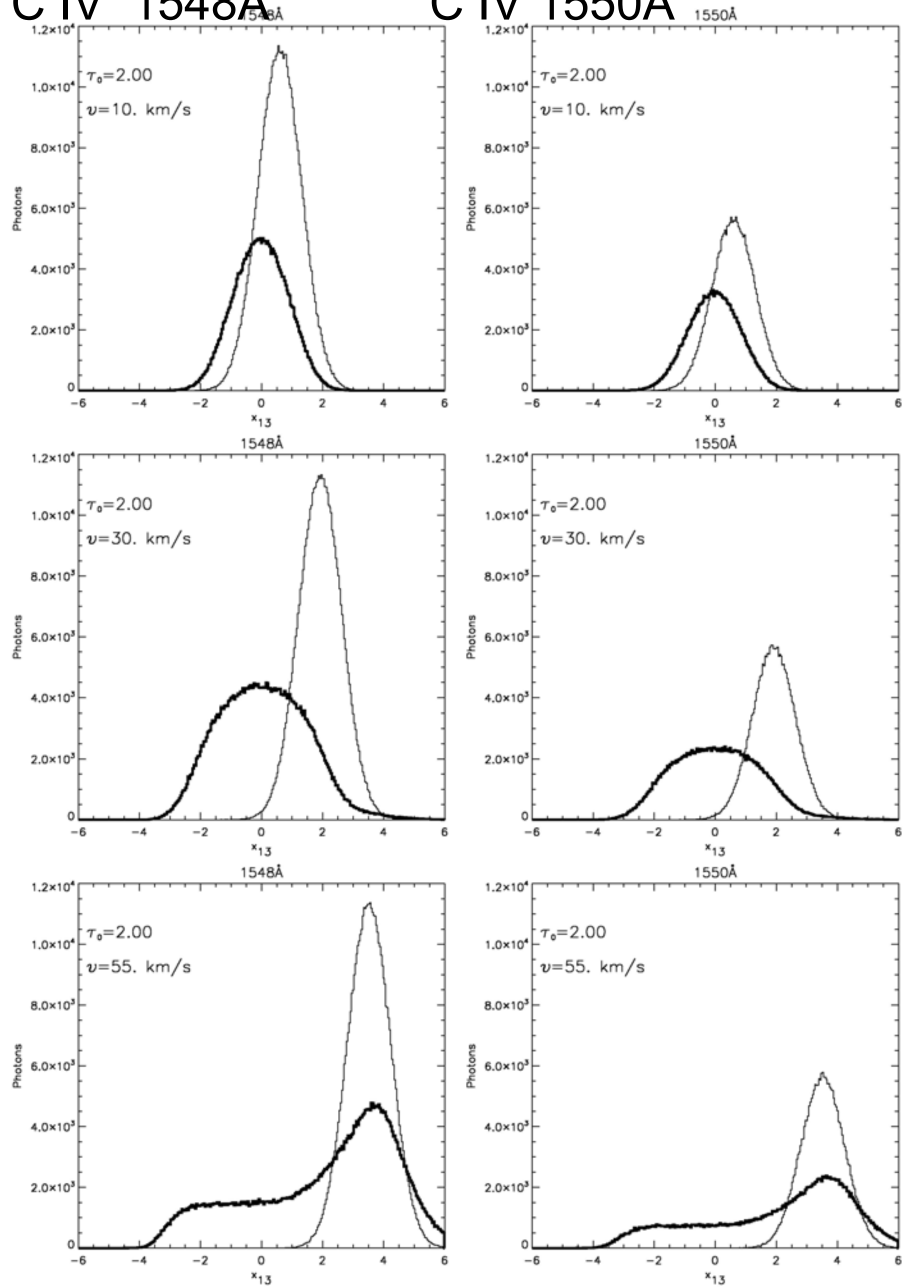
$\tau_0 = 2$

Vel= 10 km/s

Vel=30 km/s

Vel=55 km/s

C IV 1548A C IV 1550A



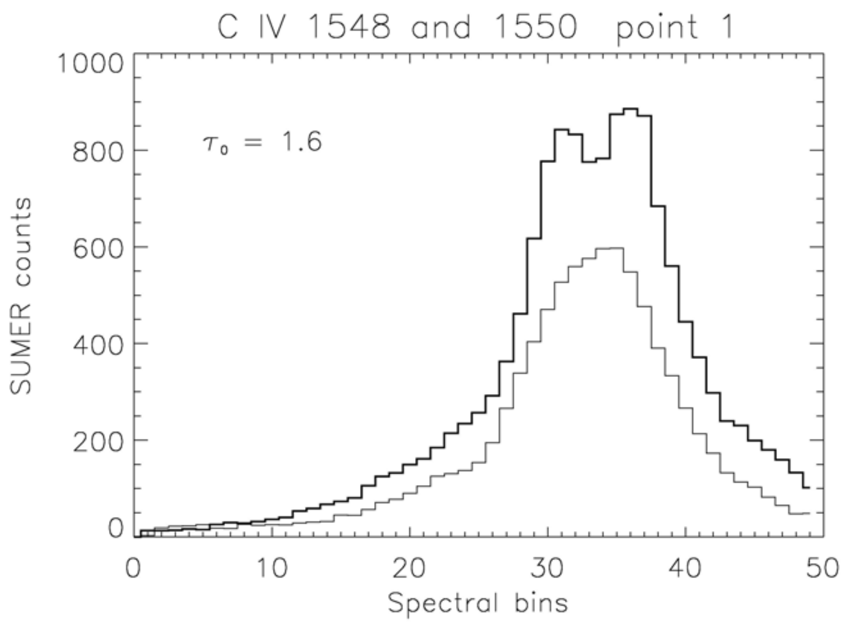
λ λ

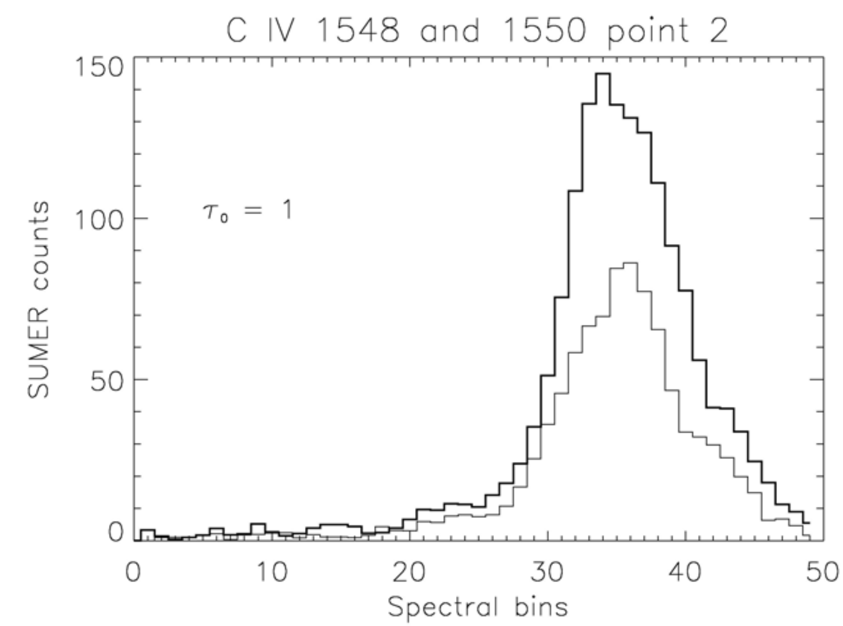
Candidate individual profiles

SUMER 15 may 1999

Active region 8541

Difference in shape between Profiles could be caused by Coherent scattering.





Conclusion

C IV 1548A and C IV 1550A spectral lines, a diagnostic for resonant scattering

Differential line asymmetry and Doppler shift explained with coherent resonant scattering.

Monte Carlo simulations well adapted for line transfer of 1548, 1550 lines when tau~1-2.

SUMER C IV data at limb

LEMUR spectrograph (Teriaca et al 2012)

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$r = I_{13}/I_{12}$ lines ratio.

$$n_e(T) = \frac{B_{13}\bar{J}_{13} - r B_{12}\bar{J}_{12}}{r\, C_{12}(T) - C_{13}(T)}$$

.

Exciting radiation fields (Rutten 2003)

$$\bar{J}_{13} = \frac{\lambda_{13}}{\nu_{13}} \frac{\Omega}{4\pi} \int I_{13}(\lambda) \phi_\lambda d\lambda$$

$$\bar{J}_{12} = \frac{\lambda_{12}}{\nu_{12}} \frac{\Omega}{4\pi} \int I_{12}(\lambda) \phi_\lambda d\lambda$$

Ω : solid angle, ϕ_λ : C IV absorption profile.