Helium line radiances in the solar corona

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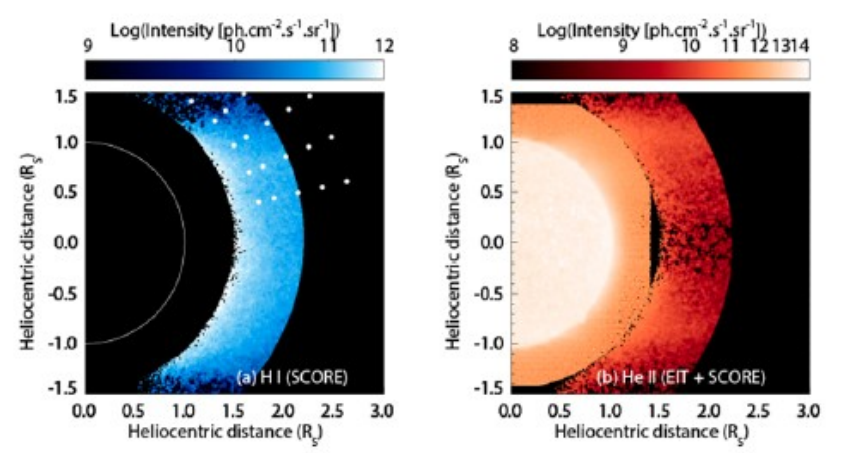
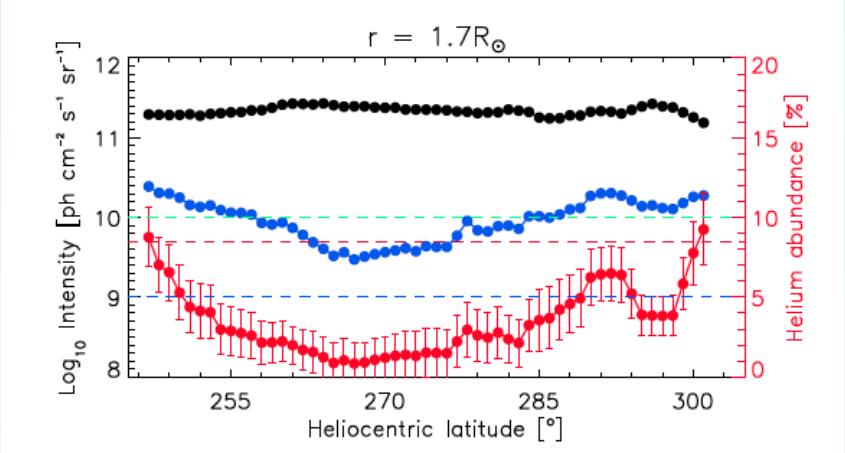
He II in corona

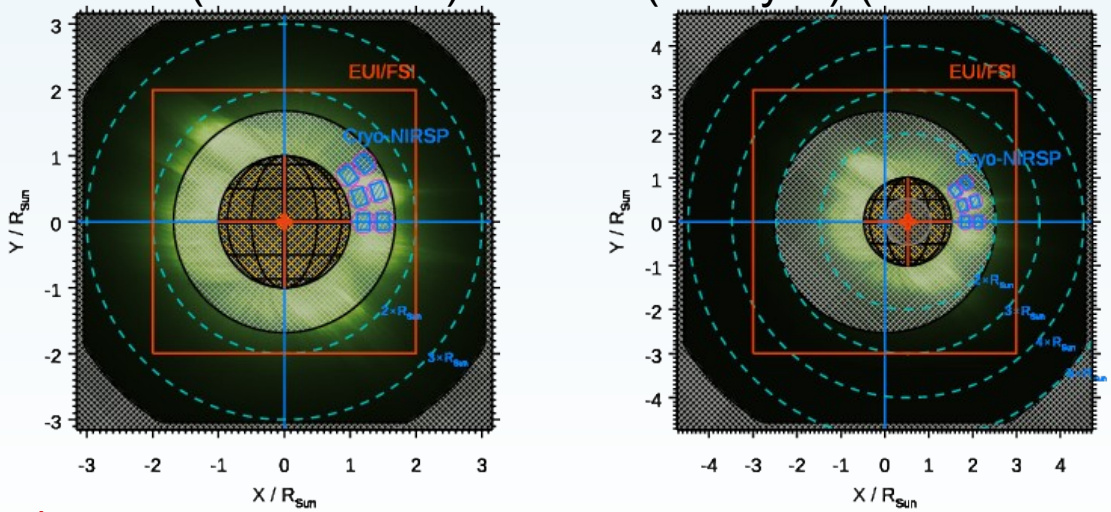
Helium abundance from He II 304 Å + H I Ly-α measurements: Gabriel+1995 (SPACELAB2/CHASE) and, more recently, Moses+2020 (HERSCHEL rocket):





Future observations:

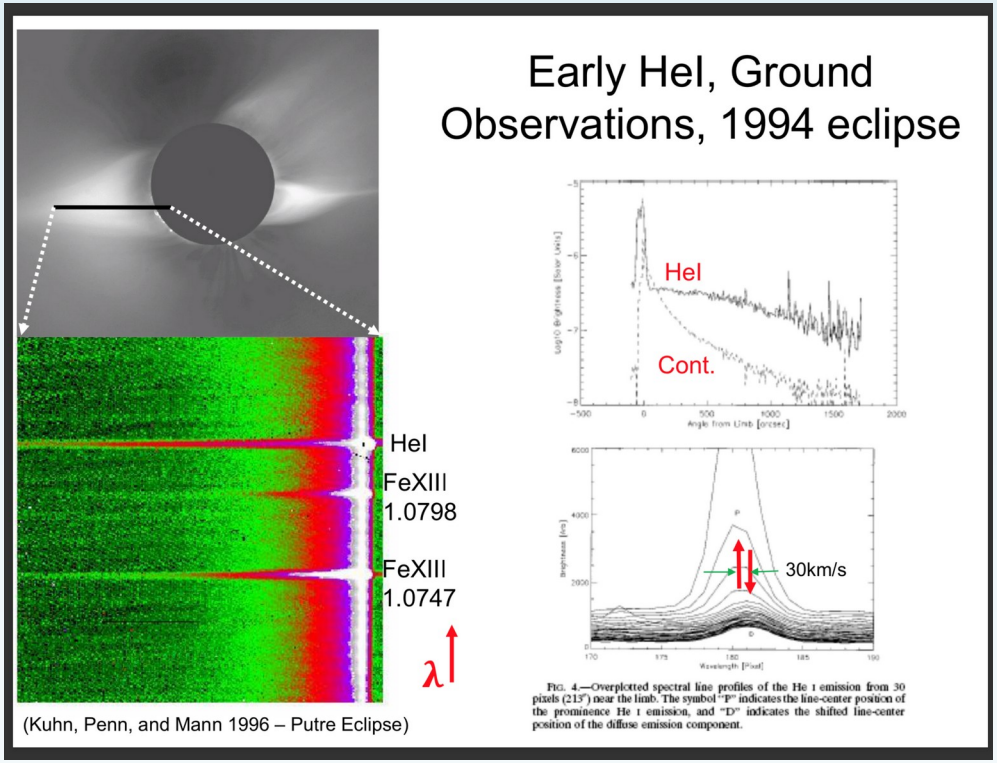
Solar Orbiter EUI/FSI (He II 304 Å) + Metis (H I Ly-α) (+ DKIST/Cryo-NIRSP?):



(See also talk by Auchère et al.:Solar Orbiter/EUI very wide field observations of the EUV corona)

He I in corona

Puzzling observations of He I in “unperturbed” corona:



Possible interpretations:

- Plasma-dust interaction? (E.g.: Moise+2010, assuming dust inner radius @ 2-4 R_{sun})
- Remnants of erupting prominences?
- Geocoronal/instrumental?

Future observations:

DKIST/Cryo-NIRSP (He I 10830 Å)
PROBA3/ASPIICS (He I 5876 Å)

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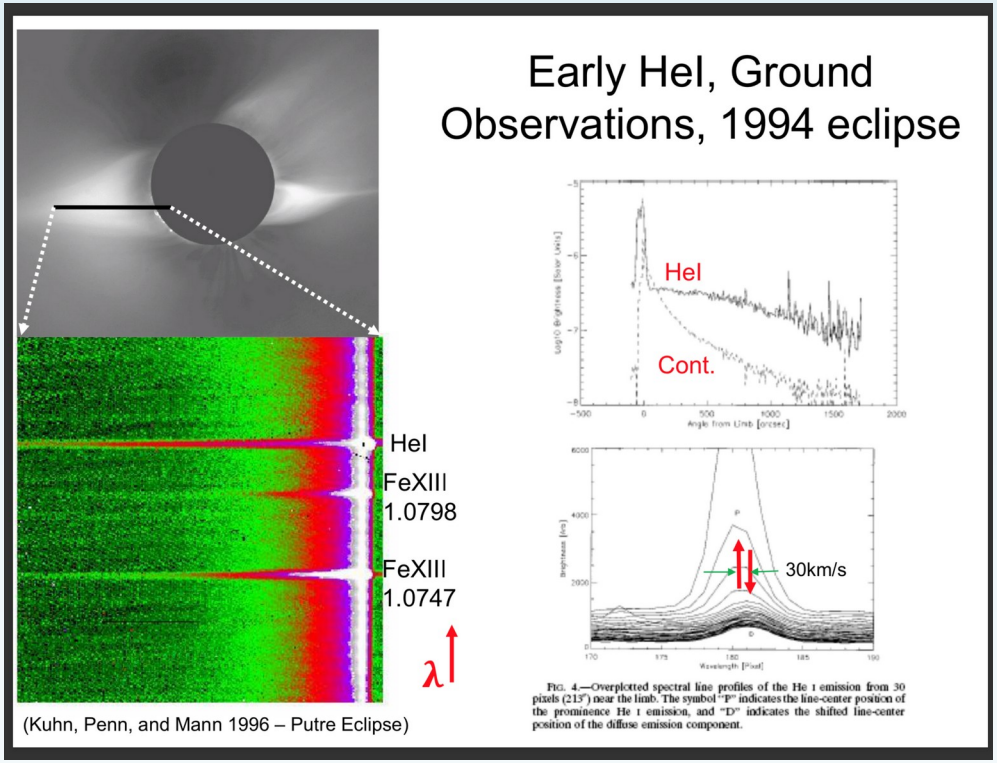

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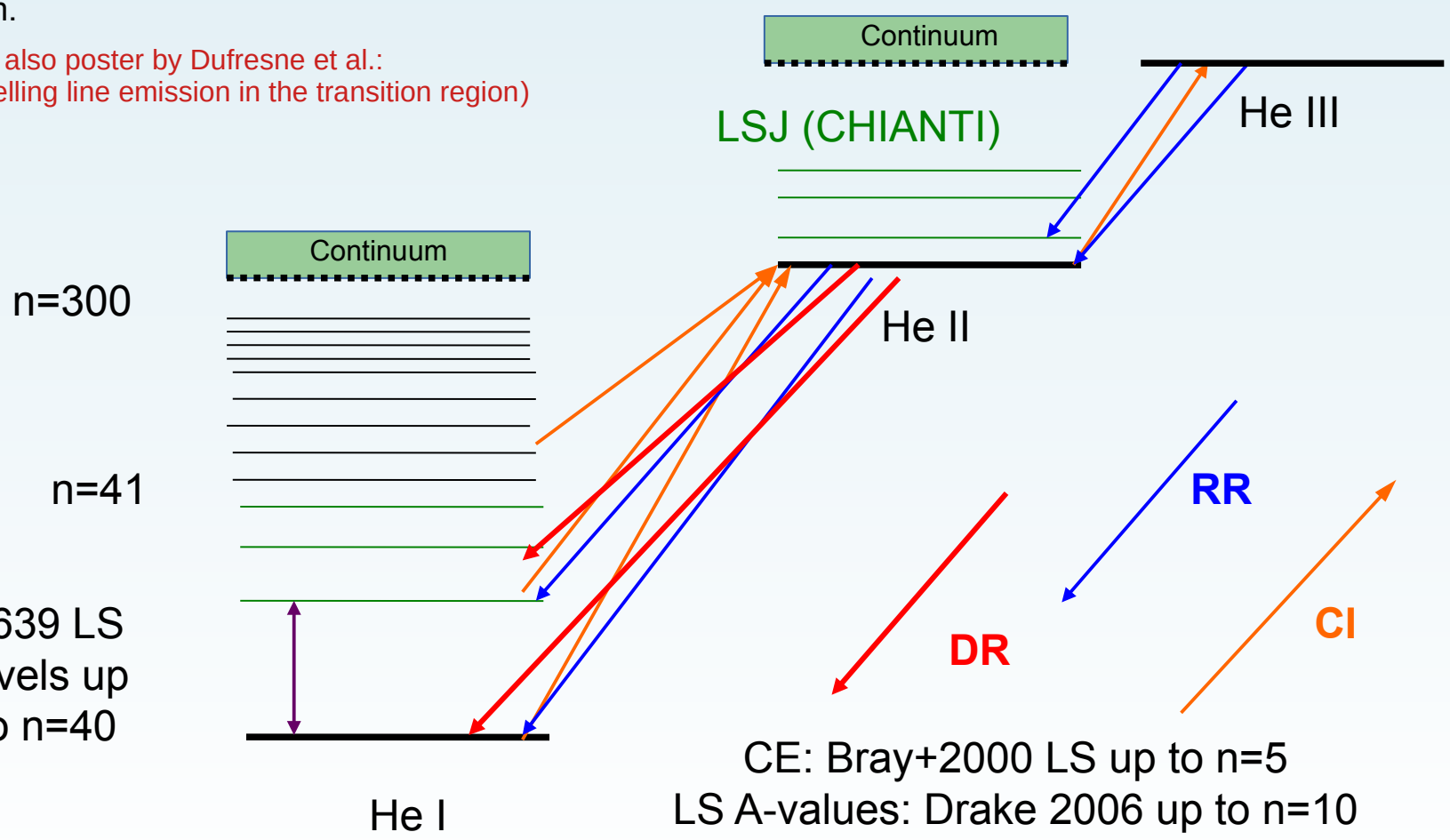
More detailed models needed

C-R Modelling: Level-Resolved

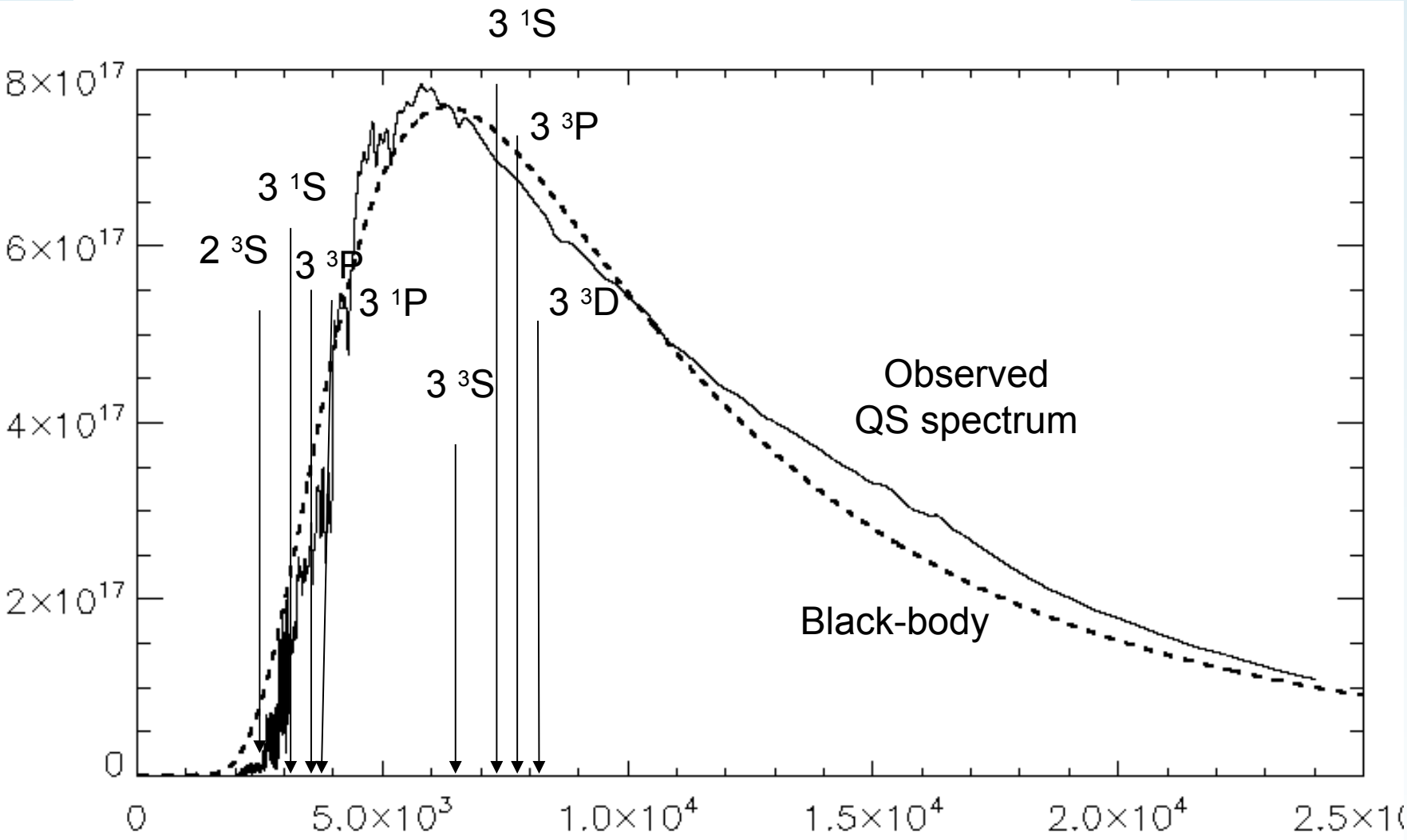
A complete and self-consistent collisional-radiative models (CRM) for helium applicable to coronal conditions. Described in detail in **Del Zanna et al. 2020 (The Astrophysical Journal, 898, 72)**

Includes, among other things, updated collisional excitation (CE) and ionization (CI) rates, dielectronic recombination (DR) rates, He^{+} and He^{++} charge exchange rates with H, in a large LS-resolved model atom.

(See also poster by Dufresne et al.: Modelling line emission in the transition region)

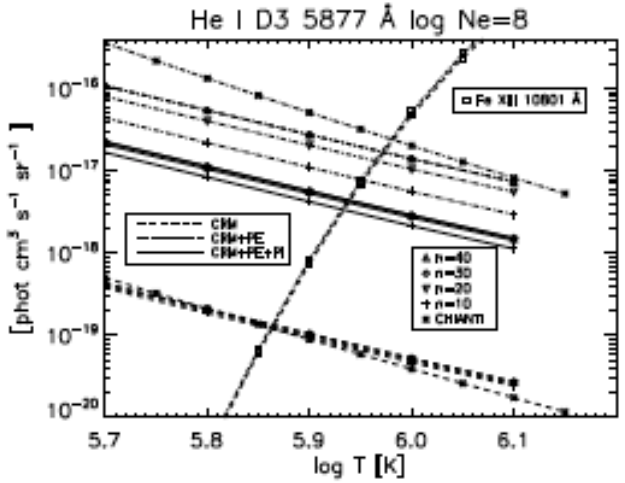


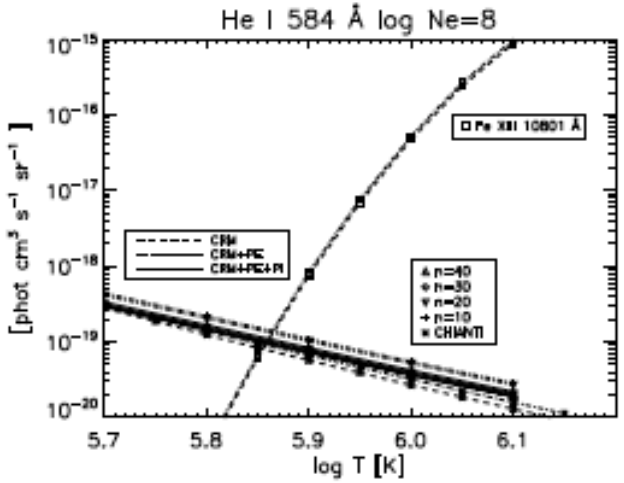
Photoexcitation/ionisation rates

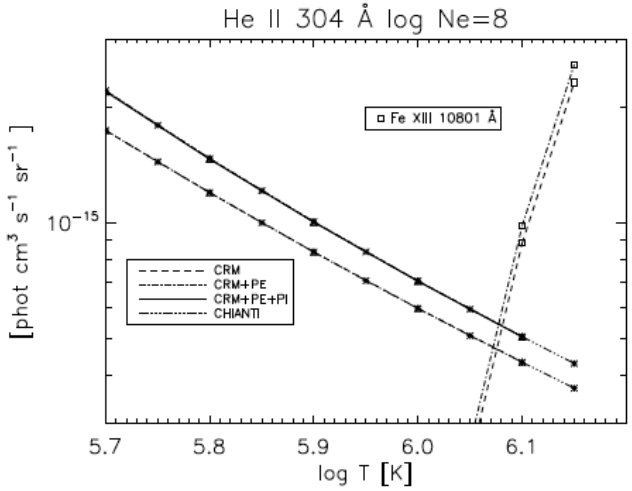


C-R Model: Emissivities

Some emissivities computed at Ne=10^8 cm^{-3}, showing the effect of photo-excitation (PE) and photo-ionisation (PI) rates, as well as of the size of the C-R model. Comparison with "standard" CHIANTI calculations is also shown.





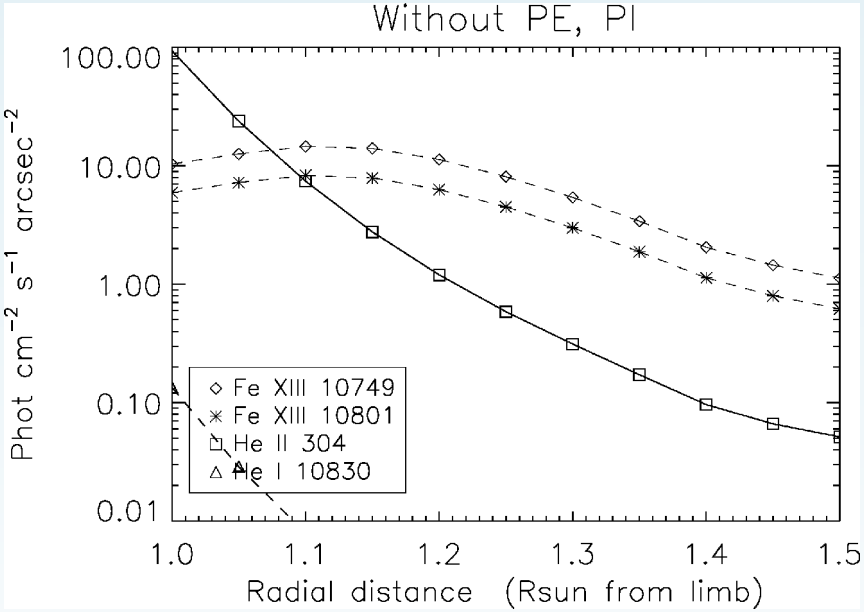


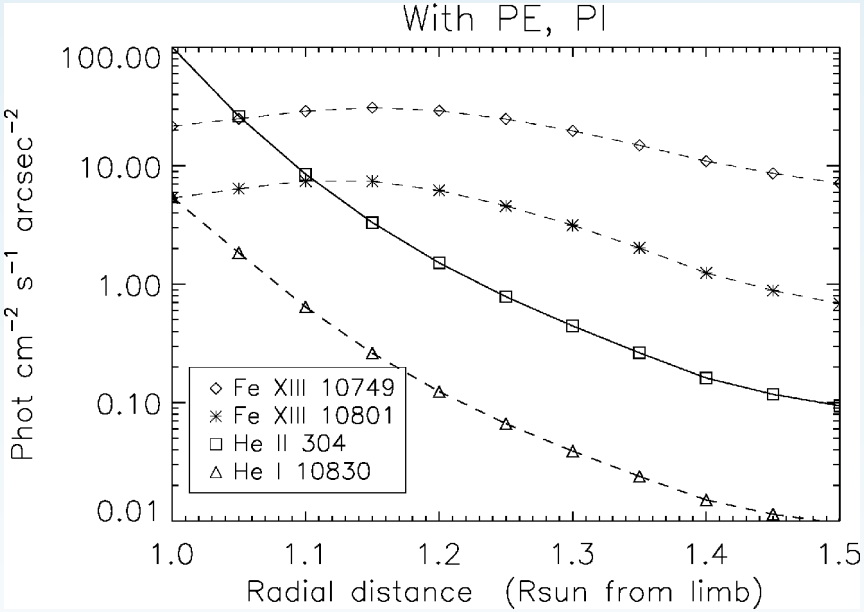
Notes:

- All optical triplet He I lines are strongly affected by both PE and PI from disk radiation: extensive CRMs are required
- He^+ Ly-α at 304 Å also significantly affected by PE and is expected to be detectable as a strong coronal line up to several solar radii.

C-R Model: Off-limb Radiances

He I 10830 Å radiances vs. Fe XIII 10747/10797 Å, along with He II 304 Å radiances, in a streamer:





Ne(h) from Del Zanna+2018, $T_e(h)$ from Vasquez+2003

Concluding remarks

- This are just first results, valid for a specific quiet Sun (streamer) coronal model.
- Work is in progress to extend these calculations to other coronal features.
- Meanwhile, work is in progress to further improve the C-R Helium model.
- Future work will include a consistent model of neutral helium production and destruction with dust ablation and orbital dynamics.
- DKIST will provide much higher resolution observations of He I in the corona, allowing discrimination between different hypotheses.
- Final remark: If observed He I lines are really of coronal origin, DKIST will provide a novel way for measuring coronal magnetic field.

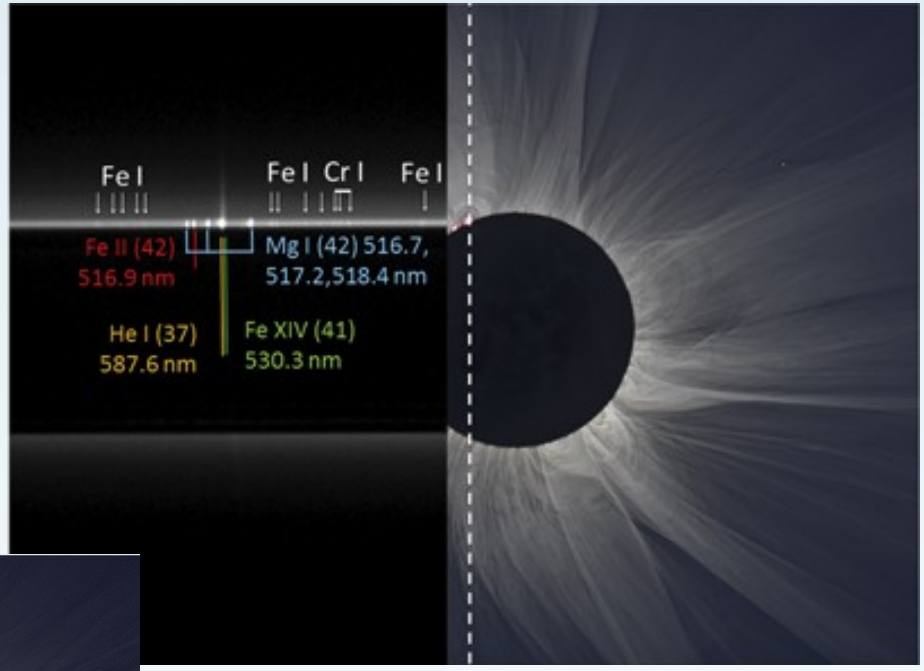
Additional material

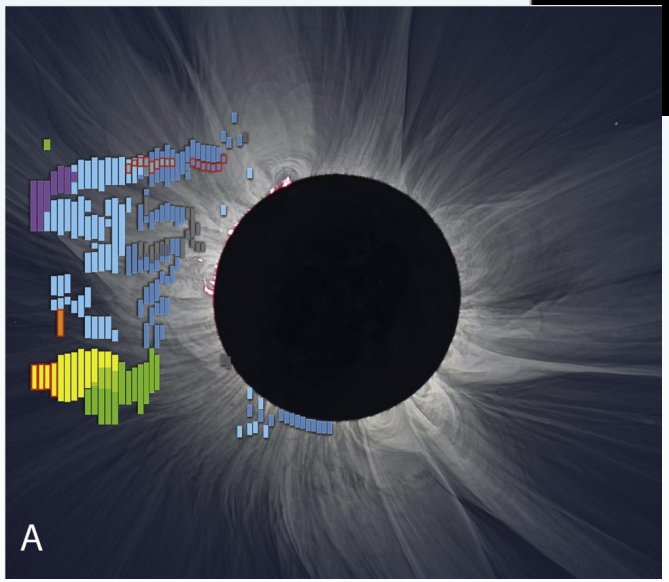
Neutrals and low-charge ions in corona

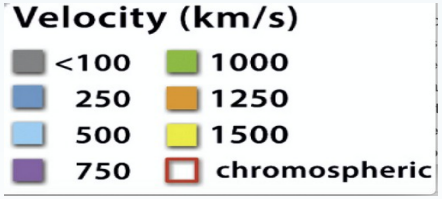
Best known example: H I: fractional density ~ 10^{-7} @ 1 MK, but high abundance. Provides great diagnostics (electron densities via Ly-α/Ly-β + white light, outflow velocities via Dopler dimming).

Heavier elements, starting from He, in erupting prominence and CMEs. Observations from SOHO/UVCS or ground-based:

Ding & Habbal 2017







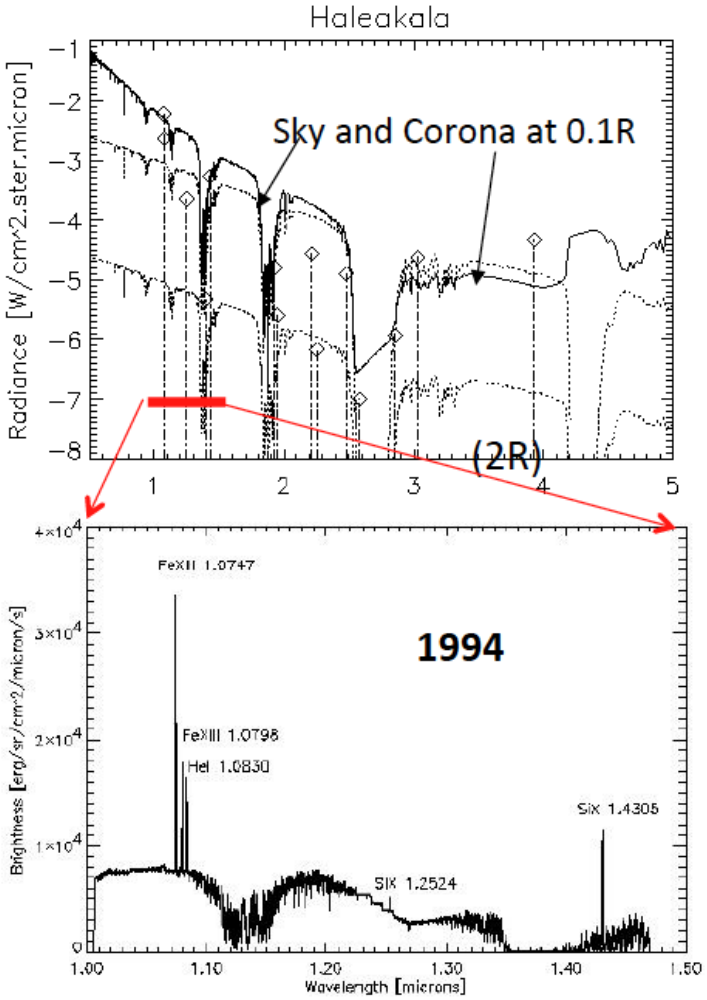
Future Observations: DKIST

(See also poster by Del Zanna et al.: Coronal forbidden lines in the DKIST era)

DKIST as a Coronagraph: Cryo-NIRSP

Temperature sensitivity from 3000K to 3MK

Wavelength (μm)	Line
0.53	FeXIV
0.637	FeX
0.789	FeXI
1.075	FeXIII
1.083	HeI
1.25	S IX
1.43	Si X
2.218	FeIX
2.326	CO
2.58	SiX
3.028	MgVIII
3.93	Si IX
4.651	CO

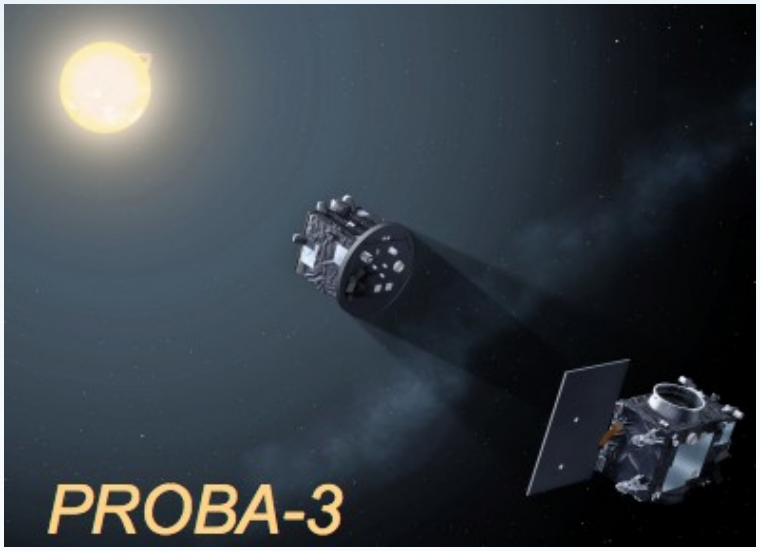


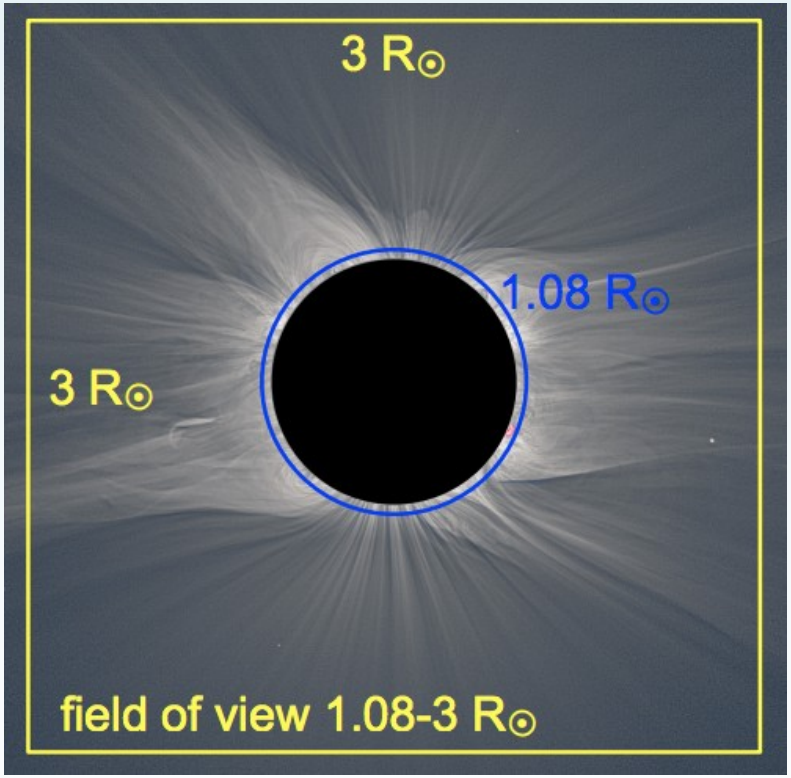
Great potential for discovery science: MHD waves, Coronal Abundances, FIP effect, etc.

Future Observations: Proba-3/ASPIICS

Proba-3: First formation-flying (150mt focal length, a few mm accuracy !)
ASPIICS (PI: A Zhukov, RO Belgium):

- 3”/px , 6” resolution
- 3 WL pB bands
- Fe XIV green 5304 A band
- **He I D3 5877 A band**





Images: A.Zhukov