Dynamics and Helium Line Formation

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Scientific Justification

The formation of helium lines in the Sun is not understood. There are at least two SOHO scientific investigations addressing this issue (PI's C. Jordan, S. Jordan). Neither of these proposals considers explicitly the effects of dynamic evolution of the emitting plasma. Here we wish to measure He I and He II (Balmer) line *profiles* as a function of time using the unique capabilities of SUMER, coupled with supporting lines formed in the corona and chromosphere and with imaging data from CDS and EIT.

Why might dynamics be important? First, Fleck and colleagues (1995 Proc. 15th NSO/SP workshop, Ed. Kuhn & Penn) have discovered some remarkable features of time series data of He I $\lambda10830$ line and the Ca II K line. The $\lambda10830$ line center and K_3 velocities vary in phase, but the former shows substantially smaller velocity amplitudes. Carlsson & Stein's (1994 ApJL) radiation hydrodynamic simulations have shown (also remarkably) that time series Ca II H profile data in the interiors of supergranule cells are consistent with a dynamic chromosphere- static models are incapable of capturing even basic elements of the line formation. Second, Helium ions have anomalously long recombination (and ionization) times t. For He I $t \sim 300/n_{10}$ sec, for He II $t \sim 100/n_{10}$ sec, where n_{10} is the electron density in units of 10^{10} cm^{-3}. These are in excess of known variablity of both chromospheric and coronal dynamcal timescales even in the quiet Sun (wide slit "movies" in Mg IX $\lambda368$, He I $\lambda584$ and O V $\lambda629$ from CDS graphically illustrate this point). Lastly, dynamical signatures can reduce dramatically ambiguities in understanding the formation of spectral features, through phase and amplitude dependencies in comparison with better understood lines.

Measuring profiles has the added advantage of providing model-independent information about the thermal properties of the emitting plasma. For instance Wahlstrom & Carlsson (1994 ApJ 433, 417) showed from linewidths of He II Ba-α from HRTS data that the plasma emitting this line was at 4×10^4K or less.

We wish to measure line profiles with SUMER at two wavelength positions measured at the He I resonance line ($1s2p\ ^1P_1^o \rightarrow 1s^2\ ^1S_0$) $\lambda584$ and at the He II Ba-γ line λ1084 respectively, using 7.5 and 10 second integration times. We would also measure profiles of lines of neutral species and of better understood transition region lines. This choice of lines will allow us to examine time dependence of He I and He II line profiles relative to lines whose formation is better understood. Fortuitously, the He II Ba-γ line can be observed simultaneously with the (on average weak) $1s3p\ ^1P_1^o \rightarrow 1s^2\ ^1S_0$ transition of He I at 537.03Å. (Ba-α and Ba-β of He II are not observable with SUMER. Higher Lyman lines are weaker and are not observable with He I lines at the same slit position.)

We wish to observe the quiet Sun in and outside of coronal holes and at least one active region. This is not only to move between different spectrum formation regimes in the importance of electron excitations versus photo-excitations, but also to look for different dynamical signatures between different solar regions. Observed profiles will be compared with those from radiation hydrodynamcal simulations.

Note that the He-II Ba-γ region of the SUMER predicted spectra in the red book is incomplete. In the red book there are three "lines" between 1082 and 1087Å, N II 1084.58, He II 1084.975, N II 1085.701. The N II lines belong to a $^3D_{3,2,1} \rightarrow^3 P_{0,1,2}$ multiplet which has 6 lines. The provisional SUMER quiet Sun atlas shows four features of comparable strength- three N II features including all 6 lines and the He II Ba-γ line. Furthermore the SUMER atlas data almost fully resolved the He II lines from N II, and show that mean quiet Sun count rates are adequate for our proposed study.

We will ask for supporting observations with the NIS mode of CDS and in the Fe IX/X channel of EIT.

Initial pointing:	3: Quiet region, Coronal hole, Active Region
slit:	1" x 300"
scan area	1" x 300"
step size	
dwell time	7.5 sec (first set of wavelengths)
	10 sec (second set of wavelengths)
duration of scan	7.5 sec (1)
	10 sec (2)
number of scans	480 for set (1)
	360 for set (2)
number of scan mirror settings	1
repointing	To follow solar rotation

total duration	2 hours
line selection	(1) O I 1152A, He I(x2) 584.334, C III 1175.71 (2) Ar I 1066.66, S III 1077.13, He I 537.03, He II 1084.93
Binning	25 per line
Compression	None

Following are Preliminary CDS and EIT contributions.

CDS Line list for the Dynamic Helium JOP:

Normal Incidence (NIS):
short exposure (20 s)

Ion	Wavelength (A)	QS cnts/s (per 2"x 2")
He I	584.33	32.9
He II (2)	303.78	24.7
O V	629.73	16.3

CDS Study Details

Spectrometer:	Normal Incidence
Slit:	90 x 240 arcsec
Raster Area:	90 x 240 arcsec
Step (DX)	0
Raster Locations:	1
Exposure Time:	20 seconds
Duration of raster:	
Number of rasters:	

Total duration: 120 minutes

Line selection: He I 584.33 A, He II (2) 607.56, O V 629.73

Bins Across Line: 25 (central 50 arcsec portion of wide slit image)

Telemetry/Compression: truncate to 12 bits

Pointing: centre of the SUMER area

Flags:

Solar Feature Tracking: yes

EIT (2.6 arc-sec pixels):

Exposure Times:
170 A (Fe IX/X) 4-8 sec

FOV: 3x3 block (~ 4 arc-min square) to match CDS+SUMER

Repetition rate: 26-30 sec or as fast as possible, Fe IX+X channel only

Total duration: 2 hr.