The Physics of Chromospheric Plasmas
ASP Conference Series, Vol. 368, 2007
Petr Heinzel, Ivan Dorotovič and Robert J. Rutten, eds.

Chromospheric and Transition-Region Dynamics in Plage

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Abstract. We study the dynamical interaction of the solar chromosphere with the transition region in mossy and non-mossy active-region plage. We carefully align image sequences taken with the Transition Region And Coronal Explorer (TRACE) in the ultraviolet passbands around 1550, 1600, and 1700 Å and the extreme ultraviolet passbands at 171 and 195 Å. We compute Fourier phase-difference spectra that are spatially averaged separately over mossy and non-mossy plage to study temporal modulations as a function of temporal frequency. The 1550 versus 171 Å comparison shows zero phase difference in non-mossy plage. In mossy plage, the phase differences between all UV and EUV passbands show pronounced upward trends with increasing frequency, which abruptly changes into zero phase difference beyond 4 – 6 mHz. The phase difference between the 171 and 195 Å sequences exhibits a shallow dip below 3 mHz and then also turns to zero phase difference beyond this value. We attribute the various similarities between the UV and EUV diagnostics that are evident in the phase-difference diagrams to the contribution of the C IV resonance lines in the 1550 and 1600 Å passbands. The strong upward trend at the lower frequencies indicates the presence of upward-traveling disturbances. It points to correspondence between the lower chromosphere and the upper transition region, perhaps by slow-mode magnetosonic disturbances, or by a connection between chromospheric and coronal heating mechanisms. The transition from this upward trend to zero phase difference at higher frequencies is due to the intermittent obscuration by fibrils that occult the foot points of hot loops, which are bright in the EUV and C IV lines, in oscillatory manner.

1. Introduction

The above abstract is copied from the journal paper describing the research presented by the first author at the meeting. In the meantime this paper has appeared as de Wijn et al. (2007). We summarize the most important results here.

This research concerns Fourier analysis of image sequences recorded with TRACE in its UV and EUV passbands. The three UV passbands at 1550, 1600, and 1700 Å sample the low chromosphere in the continuum. The 1550 and 1600 Å passbands also contain the C IV lines around 1548 Å sampling the transition region at temperatures of about 10^5 K. The EUV passbands at 171 and 195 Å sample the upper transition region ($\sim 10^6$ K). The latter images contain "moss", a highly dynamic transition-region structure. Its emission originates from the footpoints of hot, dense loops, that are intermittently obscured by chromospheric fibrils in quasi-periodic fashion (e.g., Berger et al. 1999; De Pontieu et al. 2003).

We computed Fourier power, coherence, and phase-difference spectra averaged seprately over regions of non-mossy and mossy plage, respectively.

2. Results and Conclusions

In non-mossy plage, the 1700–171 Å phase-difference spectrum show noise without indication of a particular signal. The 1550–171 Å spectrum, however, shows near-constant zero-degree phase difference. The 1600–171 Å spectrum is again very noisy, but hints at the presence of some signal. We conclude that there is common modulation in the C IV lines and the 171 Å passband, possibly through small-scale energy deposition such as reconnection, from O VI contamination in the 171 Å passband, or from coronal rain in overlying loops.

All UV–EUV phase-difference spectra show a linear trend up to about 4 mHz that corresponds to a time delay of about 7 minutes. This trend at low frequencies indicates the presence of upward traveling disturbances with periods longer than 5 minutes that cause brightness changes in the low chromosphere, and similar brightness changes in the high transition region about 400 s later. We consider that this relationship may be caused by slow-mode magnetosonic waves that travel upward. While true waves with such long periods cannot propagate, the initial or an impulsive disturbance can. We find a propagation speed of 3.5 to 11 km/s, assuming a vertical wave guide and reasonable formation heights of the moss emission. These speeds are low, but perhaps possible for slow-mode waves. Alternatively, the relationship may be caused by a connection between chromospheric and coronal heating mechanisms. In such a scenario, heating in the chromosphere would be followed by heating in the corona which would then lead to subsequent heating of the transition region through thermal conduction.

Beyond 4 mHz, the trend in mossy plage suddenly turns to zero-degree phase difference in the 1600–171 Å and 1550–171 Å spectrum. We interpret this as the result of the "shutter" action by dynamic fibrils that intermittently obscure the loop footpoints in C IV emission. The shutter instantaneously blocks both the C IV and EUV emission, thus causing zero-degree phase difference. The EUV obscuration comes from scattering out of the passband by photoionization plus subsequent recombination of hydrogen. We suspect that the C IV obscuration results from resonance-line scattering.

Acknowledgments. AdW and RJR acknowledge travel support from the Leids Kerkhoven-Bosscha Fonds and from the European Solar Magnetism Network. AdW is grateful for hospitality at LMSAL and Montana State University. BDP was supported by NASA grants NAG5-11917, NNG04-GC08G, and NAS5-38099 (TRACE).

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