日本天文学会早川幸男基金渡航報告書

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任期 (再任昇格条件)	3 年 (再任不可)
渡航目的	研究集会での招待発表と大学訪問
講演・観測・研究題目	Fine-scale structuring, braiding and heating of loops from thermal and wave instabilities
渡航先 (期間)	Cambridge & Aberystwyth, UK (2015 年 7 月 20 日〜7 月 26 日)

This research trip consisted of a presentation at an international conference followed by a visit (seminar) to a University. The presentation, whose title is the one above, was given as an invited talk at the Coronal Loops Workshop VII, which was held at the Centre for Mathematical Science at the University of Cambridge (UK) from July 21 to 23. The talk consisted of two parts, both on the subject of fine-scale structure, braiding and heating of the solar atmosphere. The first part of the talk focused on observations of fine-scale structure in the solar corona, mainly achieved through coronal rain observations. Coronal rain, a thermal instability phenomenon in coronal loops in which coronal plasma cools down to transition region (TR) and chromospheric temperatures, allows to probe the local and global topology of coronal structures at the currently highest achievable spatial resolution. Results from a recently published paper (Antolin et al, 2015, ApJ 806, 21) were presented, in which observations from multiple instruments (SST, Hinode, IRIS and SDO) are combined to show a very high co-spatial degree below $0.3''$ in the multi-thermal emission from coronal rain. Coronal rain appears multi-stranded and clumpy, indicating strong transverse and longitudinal inhomogeneity within thermally unstable loops. The strand-like and the clumpy structure extend from the chromospheric range to (at least) the TR temperature range, suggesting an important role of thermal instability in the shaping of fundamental loop substructure. A discussion followed about the ways in which such role could be accomplished. Mainly two ways were presented: through the thermal MHD mode (a solution to the MHD equations), and through the combination of flux freezing and the collapse of cooling material into thin, highly dense layers. The second part of the talk focused on 2 recently accepted papers (Okamoto, Antolin et al. 2015, & Antolin, Okamoto et al. 2015 to appear in ApJ), in which observations and simulations are combined to reveal the first direct observation (with Hinode and IRIS) and the observational signatures of resonant absorption in the solar atmosphere, a long hypothesised wave heating mechanism of the solar corona. The simulations indicate a coupling between resonant absorption and the Kelvin-Helmholtz instability, which results in heating and strand-like (thread-like) structure in the solar atmosphere, matching well the characteristic morphology observed in regions where transverse MHD waves are commonly observed (prominences, coronal rain and spicules). Throughout the workshop and especially after the presentation there was good discussion with several members of the solar physics community. Coronal rain is still a not well known phenomenon by most of the community and this presentation allowed to clarify several issues and misconceptions about the phenomenon. For instance, several researchers think that it is a rare phenomenon, which has been shown observationally already to be not true. A talk by C. Froment (Froment et al. 2015, ApJ 807, 158) further provided observational evidence for this. Also, evidence was presented in the conference from the simulation side showing that thermal instability in coronal loops can explain several of their observable characteristics (brightness, lifetime, etc.). Therefore, the results that I presented provided yet another piece of the puzzle, adding evidence to the important role of thermal instability in the solar atmosphere. The work on resonant absorption was very well received and generated an interesting discussion concerning the possibility of magnetic reconnection triggered by transverse MHD waves. A. Russel, a researcher from Dundee University (UK) suggested to quantify the amount of braiding in the numerical model, as a way to quantify reconnection. Collaboration with his group is envisaged in the near future, since they are experts on magnetic reconnection and the braiding that is produced.

The second part of the research trip consisted of a visit to Aberystwyth University on July 24 and 25 (Wales, UK), following an invitation by Dr. Youra Taroyan (one of the leaders of the solar physics group there). I gave a seminar focusing on the second part of my talk presented at the Loops Workshop, that is, on observations and modelling of resonant absorption. Dr. Taroyan is an expert on Alfvén wave theory and related instabilities. He suggested that part of my numerical results about transverse MHD waves could be explained by the presence of a resonant flow instability, in which not only the azimuthal wave is amplified but also the transverse (body) wave. He introduced me to work that he has done on this subject in the past. Further collaboration with him on this topic and also on flow instabilities induced by coronal rain is envisaged in the near future.

Overall, this 1-week research trip has been extremely fruitful and intensely packed with discussions that have triggered the start of new collaboration with different groups (especially Dundee University and Aberystwyth University). I am therefore very grateful to the Hayakawa Fund for giving me the opportunity to attend the workshop and visit the University and present my work.