RYDBERG EMISSION LINES IN THE SOLAR SPECTRUM

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Abstract. This is a latex and bibtex example for astronomy students, accompanying the manual at `http://www.staff.science.uu.nl/~rutte101/Report_recipe.html`. Note that sloppy authors wrongly use "....." instead of ".....", do not add space-making backslashes after et al., \AA, etc., do not use tildes for non-breakable spaces before units and after initials, do not end italics with \/, do not set units in roman font, do not set the e of electron in roman, do not use bibtex, do not use a spell checker, do not use the url command for websites, do not link citations to NASA's ADS, and probably do not do much else well.

1. Introduction

The existence of two emission features in the solar spectrum near 12 μm was announced by Murcray et al. (1981), but only when they were informed by L. Testerman and J. Brault that they had noticed them too. Before that, Goldman et al. (1980) had white-pasted them out of their spectrum atlas in the mistaken belief that all solar and telluric lines should be in absorption. We explained these emission features many years ago (Carlsson et al. 1992, henceforth Paper I; see also Rutten & Carlsson 1994)[1].

2. Model computations

2.1. Background

In the solar photosphere NLTE departure diffusion occurs in the upper reaches of the Mg I term structure (see Paper I for detail). It is akin to optically-thin collisional-radiative recombination along Rydberg levels in tenuous plasmas (Fig. 1)[2].

2.2. Method

We solved the statistical equilibrium and radiative transfer equations for all relevant levels and frequencies in Mg I and Mg II for various models of the solar atmosphere, including the standard one formulated in the monumental papers by Vernazza et al. (1973, 1976, 1981).

3. Conclusion

Our computation explained the formation of the enigmatic Mg I 12 μm emission features. They arise through population depletion by line photon losses and population replenishment from the ionic reservoir through highly excited levels. A Rydberg-channel replenishment flow is realized by collisionally-dominated population diffusion via ladder-wise departure divergence (see Fig. 1 in Sect. 2).

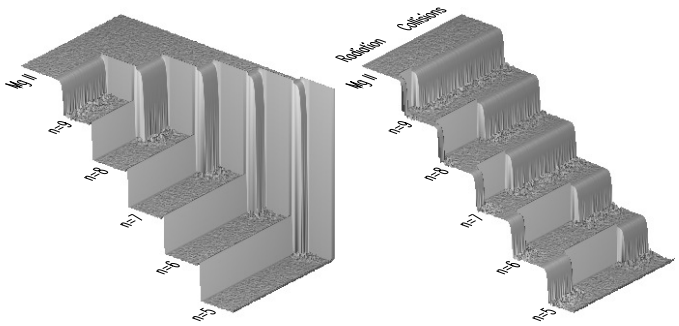

Fig. 1. Collisional-radiative recombination along Mg I Rydberg states visualized for pool-drop kayakers. The lefthand sketch shows that the largest recombination flow from the magnesium population reservoir in the Mg II ground state is into the highest Mg I level ($n = 9$ in our model). The righthand sketch shows that along the $\Delta n = 1$ downward ladder the flow is initially dominated by collisional transitions but that radiative transitions take over. The flow is driven by photon losses in strong Mg I lines and is balanced by radiative ionization in ultraviolet edges. Similar Rydberg flows occur in other elements, but the Mg I Rydberg levels have the largest photospheric populations, even exceeding the hydrogen ones. From Rutten & Carlsson (1994).

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References

Carlsson, M., Rutten, R. J., & Shchukina, N. G. 1992, A&A, 253, 567 ADS (Paper I)
Goldman, A., Blatherwick, R. D., Murcray, F. H., et al. 1980, NASA STI/Recon Technical Report N, 80, 31298 ADS
Murcray, F. J., Goldman, A., Murcray, F. H., et al. 1981, ApJ, 247, L97 ADS
Rutten, R. J. & Carlsson, M. 1994, in IAU Symp. 154: Infrared Solar Physics, 309 ADS
Vernazza, J. E., Avrett, E. H., & Loeser, R. 1973, ApJ, 184, 605 ADS
Vernazza, J. E., Avrett, E. H., & Loeser, R. 1976, ApJS, 30, 1 ADS
Vernazza, J. E., Avrett, E. H., & Loeser, R. 1981, ApJS, 45, 635 ADS

[1] Clicking on citations should open the corresponding ADS abstract page in a web browser but you may have to permit web access, for example for Adobe Reader with the Trust Manager under Preferences. Likewise, hovering over an acronym should pop-up its meaning in Adobe Reader but not with some other pdf viewers.

[2] Figure production: I usually prepare separate figures, each with full axis annotation, and paste these together into multi-panel layout using the latex commands in `cutmultipanel.tex`. They remove superfluous axis annotation between adjacent panels and rescale them to the same size. This way I choose the assembly layout while writing the paper.