THE Ca II EMISSION LINES IN QUIESCENT PROMINENCES

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(Received 23 September, 1976)

Abstract. Observations of the Ca II H, K, and infrared triplet lines are compared with theoretical predictions from the slab models of Heasley and Milkey (1976). While the theoretical models describe the hydrogen and helium emission spectra of quiescent prominences satisfactorily the predicted Ca II lines are systematically too bright. The most likely reason for the discrepancy is the inapplicability of the symmetric slab prominence model for lines which become even moderately optically thick in prominences.

1. Introduction

The slab models of quiescent prominences developed by Heasley and Milkey (1976) have provided a reasonable theoretical starting point for the interpretation of the hydrogen and helium spectra in these objects. A basic difficulty with the theoretical modeling procedure is that the visual spectra of hydrogen and helium alone are insufficient to adequately limit the range of physical parameters (temperature, pressure, electron density, etc.) present in prominences. Further constraints, in the form of observations of other spectral lines, are thus required. In the visual region of the spectrum the Ca II resonance lines and infrared triplet are well suited for this purpose both observationally and in terms of theoretical interpretation.

The purpose of this paper is to compare the predicted Ca II spectra from the Heasley and Milkey (1976) models with recent well calibrated observations of the Ca II emission lines in quiescent prominences (Engvold, 1977; Landman and Illing, 1976b). We find that while these models are able to satisfactorily describe almost all available hydrogen and helium observations the predicted Ca II lines are approximately a factor of two to three brighter than the observations. We believe that the present discrepancy between the observations and theory results from the inapplicability of the canonical symmetric slab model of prominences for lines which are even moderately optically thick in these objects (e.g., the Ca II H and K lines).

* Operated by the Association of Universities for Research in Astronomy, Inc., under contract with the National Science Foundation.
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2. Comparison of the Theoretical Ca II Spectra with Observations

For a given prominence model the solution of the non-LTE calcium problem is straight-forward. To date the most complete study of the Ca$^+$ emission lines in prominences is that of Ishizawa (1971). She computed integrated line emissions for an extensive grid of uniform slab models for a range of temperatures, electron densities, and K line optical depths relevant to prominences. While her grid provides an adequate basis for the study of the relative inter-relation of the 5 relevant Ca$^+$ lines the use of the highly schematized slab models precludes an intercomparison of the Ca$^+$ and hydrogen lines on an absolute scale. It is this problem we address in this paper.

The atomic parameters for Ca$^+$ (oscillator strengths, photoionization cross sections, collision rates, etc.) are reasonably well known. For the calculations reported here we have adopted the relevant physical parameters from the compilations of Shine (1973) for a 5-level model atom plus continuum. The radiation illuminating the prominence in the various transitions was treated as described by Heasley et al. (1974). We have adopted the dilution factors, $W$(H, K) = 0.25 and $W$(8498, 8542, 8668) = 0.32, pro-

![Fig. 1. Comparison of $I(D_3)$ vs $I(H\alpha)$ for the prominence of 22 April, 1974, $PA = 120^\circ$ (dots) observed by Engvold (1977) and the theoretical results for the isobaric–isothermal models of Heasley and Milkey (1976). The squares refer to models with $T = 7500$ K and $p = 0.065$ dynes cm$^{-2}$ and the open circles for models with $T = 9500$ K and $p = 0.065$ dynes cm$^{-2}$.](image)