HIGH RESOLUTION SPECTROSCOPY OF
SOLAR ACTIVITY

I. Observing Procedures

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Abstract. We describe an observing program designed to obtain high spatial resolution photographic spectra of solar active region phenomena, with time resolution as short as 6 s. The Vacuum Tower Telescope and Echelle Spectrograph at Sacramento Peak Observatory are used to make observations simultaneously in Hα, He D3, Ca II K, Mg b, the CN bandhead at λ3883, and the magnetically-sensitive line Fe I λ6302. Images reflected from the slit jaw are exposed simultaneously in white-light and Hα. Observations of chromospheric heating, following a high-velocity infall along an Hα superpenumbral filament, are presented to illustrate the capabilities of the program.

1. Introduction

The spectroscopic study of fine structures in solar active regions is an important supplement to the large number of observations that have been made with narrow-band filters. While the latter observations are of tremendous value in studying morphological properties of solar activity, and of some value in providing coarse line profile data by using a rapidly-tunable filter, at present only spectroscopy can provide the kind of detailed information required to diagnose reliably the physical conditions in the radiating source volume. Compared with filter observations, there have been relatively few spectroscopic studies of active region phenomena. For example, there are only a very few published Hα line profiles in solar flares, yet these profiles are of crucial importance in understanding the processes involved in flare-induced chromospheric heating.

In an attempt to provide critical spectroscopic data during the current solar maximum period we have begun a project with the Vacuum Tower Telescope and Echelle Spectrograph at Sacramento Peak Observatory. The program exploits the possibility of obtaining simultaneous observations in widely separated spectral lines. We have chosen lines which span the height range accessible with ground-based observations, and which are suitable for diagnosing the physical conditions in active region sources. The present program is similar in concept to the successful HIRKHAD project (Beckers et al., 1972), the main difference being a selection of lines more appropriate for work on solar activity. As with the HIRKHAD program, we propose to make observational material resulting from the project available to interested astronomers. We will endeavor to obtain high quality spectra of a variety

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of active region phenomena, including flares, plages, surges, sunspots, filaments and Ellerman bombs. The acronym for the project is SOAP, for Spectroscopic Observations of Active Phenomena.

2. Instrumental Details and Observing Procedures

A. INSTRUMENTATION

The Vacuum Tower Telescope and Echelle Spectrograph at Sacramento Peak Observatory have been described by Dunn (1964, 1969). The 76 cm aperture telescope produces a 51 cm solar image on the slit of the spectrograph. Light reflected from the slit-jaws is observed by photography (white light and Hα filtergrams) and by TV cameras to monitor the alignment and guiding of the instrument with respect to white light features and Hα fine structure. Light entering the spectrograph is predispersed by a prism monochromator. A set of slits in the monochromator focal plane then selects narrow spectral bands around the lines of interest. This light reflects from an echelle grating to form a set of partially-overlapping, high dispersion spectra at the focal plane. Glass filters are used to isolate the desired spectral lines which are recorded photographically.

The grating has 79 lines per mm, and is blazed at 63°4. To conveniently position the chosen lines across the focal plane, the grating is used at 64°6. This produces only a slight decrease in efficiency. The image scale is approximately 290 μ:1 arc sec, and the projected length of the slit is about 220 arc sec. For most observations the slit width will be 200μ – about 0.7 arc sec. With this slit width, the exposure time at disk center is about 3 s. The exposure time is automatically corrected for limb darkening and variations in image brightness (due to changes in sky transparency and air mass) to produce uniform exposures. The film magazines can be advanced in about 2 s, so that an exposure rate of 6 s is possible. Since about 400 frames can be contained in the magazines, uninterrupted observing sequences of 40 min are available at this rate. The solar image can be rapidly repositioned between exposures, under flexible and reproducible computer control. A recently-implemented laser alignment system guides the image on the slit-jaws with an accuracy of a few arc seconds over several hours.

B. OBSERVED LINES

Table I lists the important parameters of the lines observed in this program. Working within the constraints of the overlapping echelle orders and the space needed for each film magazine at the focal plane, we have endeavored to select a set of lines suited to activity studies. We chose Hα because it is most-commonly observed in filters, and because it is a useful chromospheric diagnostic in the fine structure. The Ca II K line is a very useful chromospheric and upper photospheric diagnostic. While studies of the formation of He D₃ are difficult because of competition between collisional and photo-excitation, the line provides information on the hotter parts of