SPECTRAL OBSERVATIONS OF RED DWARFS II. NEW OBSERVATIONS OF FLARE STARS IN THE PLEIADES CLUSTER REGION

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We studied the spectra of 24 flare stars of the Pleiades cluster region obtained on the 2.6m telescope of the Byurakan observatory in the years 1986-1989. From the spectral indices of titanium oxide (TiO) and other chemical elements of the stars investigated we determined their spectral classes and luminosities (absolute visual stellar magnitudes). The agreement of these moduli of the stars with the distance modulus of the Pleiades cluster confirms that 21 of them belong to the cluster. Only three of them (FSP 169, FSP 377, and FSP 435) are possibly not members of the cluster. This indicates that the flare activity of a star is a reliable criterion for its membership in a nearby stellar system (cluster or association).

1. Introduction. In the first paper of the present series [1] we gave the results of a study of the spectra of 17 flare stars in the Pleiades region obtained using the 6m-telescope of the Special Astrophysical Observatory (Russia). The spectra of 14 stars contained emission lines of the Balmer hydrogen series and the H and K lines of ionized calcium, as well as strong bands of the molecules TiO, CaH, MgH, and others. For these 14 stars the R - I color index, spectral class, and absolute stellar magnitude were determined from the spectral indices of the titanium oxide bands TiO using a method proposed by Stauffer and Hartmann [2, 3].

The spectra obtained showed a complete agreement of the spectra of flare stars of the Pleiades cluster with spectra of flare stars of UV Ceti type in the solar neighborhood. This fact is a new argument in favor of the concept that all these objects form a single class of flare stars having flare activity and passing through one of the stages of evolution of red dwarf stars [4].

Also worthy of attention is the completely independent evidence obtained in favor of the evolutionary status of flare stars. It turned out that the overwhelming majority of red dwarf stars of the Pleiades cluster studied by Stauffer [5], being young stars that have not yet reached the main sequence on the Hertzsprung-Russell diagram (pre-main sequence stars), appear in the catalog of flare stars by Haro, Chavira, and Gonzalez [6]. There are grounds for believing that the other stars of this list are also flare stars.

In the present paper we study the results of spectral observations of another 24 flare stars of the Pleiades cluster region.

2. New observations of the spectra of flare stars in the Pleiades. Spectral observations of flare stars of the region of the Pleiades cluster were carried out in the years 1986–1989 at the Byurakan Astrophysical Observatory of the Armenian National Academy of Sciences.

The observational material obtained is presented in Table 1, where the successive columns contain: Star number (FSP) in the flare star catalog of the Pleiades region by Haro et al. [6], date of observation, spectral range, and number of spectrograms.

The spectra were obtained on the 2.6m telescope using the UAGS universal diffraction spectrograph and an image converter tube. The observations were carried out using a 651/8 diffraction grating with linear reciprocal dispersion of 100A/mm and emulsions of types Kodak 103a0, A500V and A600H. The dispersion curves were constructed using a spectral lamp filled with He-Ne-Ar.

All spectra were calibrated using the tube photometer of the Byurakan Observatory. To standardize the spectra of the stars studied the spectra of standard stars were obtained from the paper of Bares and Hayes [7] at the closest possible zenith distances.

The spectra were recorded using the PDS-1010A automatic microdensitometer of the Byurakan Observatory.

The spectra were scanned for the most part using a slit of size 50mcm × 50mcm. In all cases the scanning step was chosen to be half the width of the scanning slit.

The construction of the dispersion curves, linearization of the wavelength scale, and the construction of the characteristic curves for transition from darkenings to intensifications, Gaussian filtering, correction of the spectra for the spectral sensitivity of the system, and plotting of the spectrograms, determination of various spectral parameters, etc., were carried out semi-automatically using the AIDA system for analyzing spectra developed in the Byurakan observatory on a personal computer of PC/AT type using the ADA language [8].

**General form of the spectra obtained.** The spectra of flare stars of the Pleiades region obtained by us cover mostly the region 4500–7300 Å. The strong narrow absorption D line of neutral sodium Na I, and the emission lines of hydrogen and ionized calcium of moderate intensity are prominent in the spectra of all the stars observed. In some spectra weak absorption bands of titanium oxide and other molecules are also seen.

The record of the spectrum of the flare star FSP 256 gives a general idea of the spectra obtained (Fig. 1).

The flare stars we studied are comparatively bright and therefore approximately half of them had been