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OSAWA'S PECULIAR STAR HD 221568*

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ABSTRACT

This Letter briefly discusses the first scanner observations of the continuum of an extraordinary peculiar A star, HD 221568, and calls attention to the additional peculiarities of this object.

I. INTRODUCTION

HD 221568 was found by Osawa (1965) to have one of the largest light variations known among the peculiar A stars. Osawa and his collaborators initiated an extensive series of photometric and spectroscopic observations of the star. This body of data was discussed by Kodaira (1967), who found that HD 221568, when it is bluest, is similar to a star of type B9 IV–V, and that variations observed in the *uvby* system could be explained by suitable deviations of the atmosphere from radiative and hydrostatic equilibrium.

Recent scanner observations of the continuum confirmed earlier results at the blue phase but indicated that deviations from equilibrium would not fully account for the peculiar flux distribution at the red phase, if hydrogen is assumed to be the only important source of opacity. This Letter briefly discusses the new observations of the continuum of HD 221568 and calls attention to the additional peculiarities of this object.

II. OBSERVATIONAL RESULTS

The observations were made with the Cassegrain scanner of the 60-inch telescope at Mount Wilson during three separate runs: August 9/10, September 6/7 and 7/8, and October 4/5 and 5/6, 1968. These runs correspond to phases 0.851, 0.021, and 0.203, respectively ($P = 159.3$ days; Osawa 1969). The scans were made with a 50-Å band pass in the region 3290–5840 Å and with a 100-Å band pass in the region 5255–7850 Å. Appropriate standards were observed frequently each night. The data, reduced to Oke's (1964) system, are shown in Figure 1. The *uvby* photometry of Osawa agrees with the present scan observations. Note that the August data agree with those of September, while the October data clearly show a different trend. We drew in the approximate locations of the continua corresponding to "red" and "blue" phases of the color variation. The scan data revealed that the flux excess at the red phase extends far into the red and near-infrared. In the Balmer continuum, however, this separation is not clear, because of the scattering of the observed points. The scattering seems to be intrinsic and suggests that the ultraviolet flux probably varies in a short time interval. Finally, we point out depressions in the continuum at approximately 4200 Å (2.35 μ^{-1}), 5300 Å (1.90 μ^{-1}) and, at the red phase, 6300 Å (1.55 μ^{-1}). High-dispersion spectra were used to estimate the effect of line blocking in the regions 4000–4500 and 5000–5500 Å. While

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the blocking in each band varies considerably ($\delta m \lesssim 0.03$) during the cycle, it is essentially uniform ($\delta m \lesssim 0.01$) over these spectral regions at any given phase. We conclude that these features represent real depressions in the continuum of this peculiar object.

III. BLUE PHASE

Figure 2 shows a comparison of the observed continuum at the blue phase and the theoretical continua calculated by Mihalas (1966). The observed data are normalized to the blanketed model of Vega, $\theta_e = 0.525$ and $\log g = 4.0$ (see Kodaira 1969; Mihalas 1966). We found the optimal fit for $\theta_e = 0.45$ and $\log g = 4.0$, assuming a large interstellar reddening, $E(B - V) = 0.133$ mag kpc^{-1}. This blanketed model atmosphere also gives an Hγ profile identical with the observed one at the blue phase. Osawa's (1969) photometry of nearby stars suggests an interstellar reddening $E(B - V) = 0.50$

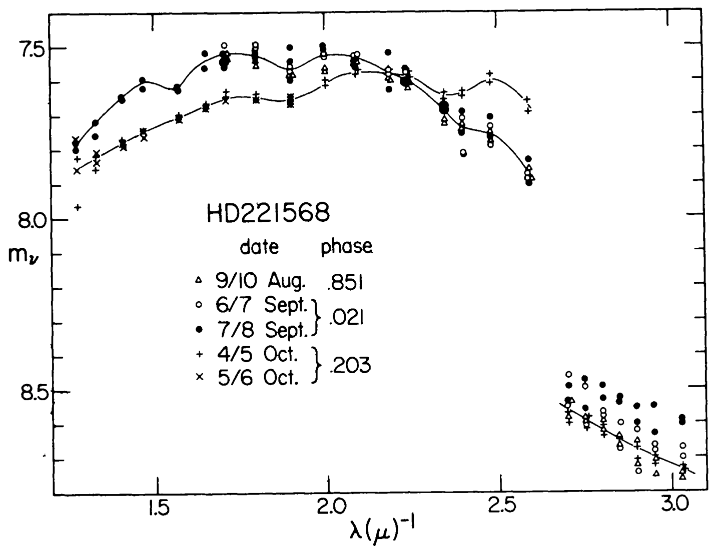

FIG. 1.—Observed monochromatic magnitudes of HD 221568

mag kpc^{-1}, which gives a distance of 270 pc for HD 221568. The interstellar absorption $A_V = 3E(B - V) = 0.40$ and the observed brightness $V = 7.66$ lead to an absolute magnitude $M_V = -0.15$. All these facts are consistent and confirm the earlier conclusion that HD 221568, at the blue phase, is very similar to a main-sequence B9 star. It should be noticed that the scale of effective temperatures was changed from the unblanketed system, $\theta_e = 0.50$, in Kodaira (1967) to the present blanketed system, $\theta_e = 0.45$.

IV. RED PHASE

At the red phase the excess radiation amounts to almost 0.05 mag at 8000 Å, and probably to less than that, shortward of the Balmer discontinuity. The assumption of a hydrogen-dominated opacity indicates that the near-infrared radiation and the near-ultraviolet radiation originate at nearly the same depth. It is then impossible to define a unique temperature excess for that optical depth in the manner originally proposed. One can calculate modified model atmospheres which account for the variations in vby, infrared flux, and Hγ profile, but none of them account simultaneously for the behavior of u and the sharp Hα profile at the red phase. We remark that in Figure 1 the ultraviolet points for September 7/8 are located systematically higher than those for September 6/7, while the data of both nights are essentially the same in the blue and yellow regions. The infrared data for the red phase are available only for September 7/8, when the ultraviolet excess was recorded. Before the original working hypothesis is abandoned, we should determine whether the short-interval variation in the ultraviolet is related to the flux variation in the infrared.

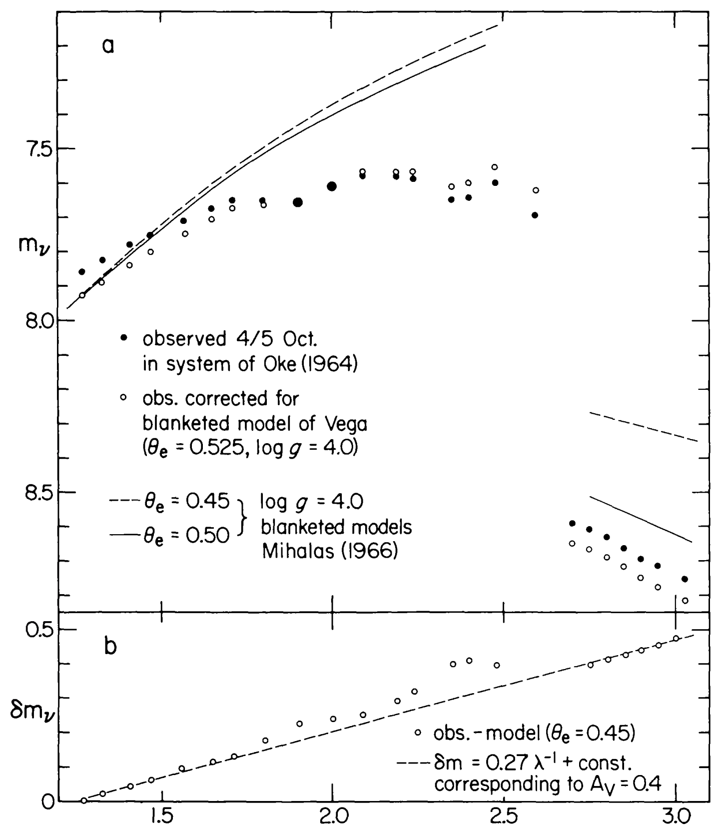

FIG. 2.—Comparison of observed data with the theoretical continua. (*a*) Comparison of the flux distribution; (*b*) effect of interstellar reddening.

The assumption of a pure-hydrogen opacity clearly cannot explain the depressions in the continuum at 4200, 5300, and 6300 Å that occur in intervals small compared to the wavelength-dependent variation of the Planck function or the hydrogen continuous opacity. Efforts were made to find a possible new opacity source among chemical elements which are abundant in the red phase, including neutral silicon. The result, however, is negative so far. If the additional opacity still turns out to be effective in the blue phase, the parameters obtained for this phase must be modified accordingly.

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