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FLARE OBSERVED FOR A HIGH VELOCITY STAR

During the night of March 12/13, 1988 a relatively strong flare was observed for the high proper motion star G64-34 (=LTT5465) at the San Pedro Martir Observatory, Baja California, Mexico, using the Danish 6-channel uvbyβ photometer that has been in operation there since 1983. This star was observed as part of an ongoing extensive uvbyβ photometric survey of high-velocity and metal-poor stars (Schuster and Nissen, 1988). G64-34 has been selected from Table II of Fouts and Sandage (1986) who give V=11.98 and B-V=1.01 on the system of Johnson and a radial velocity of +25.7 km/sec; these values are based on only one photometric observation and only one radial velocity measurement .

The observations of the flare were made simultaneously in the bands u, v, b, and y of the Strömgren photometric system. A few Hβ observations were also obtained. The uvby instrumental magnitudes are plotted in Figure 1 corrected only for sky brightness and for changes in atmospheric extinction between the beginning and end of the flare. Small vertical error bars to the left in the figure show the errors expected only from the photon statistics, and a small horizontal bar near the top, center shows the integration time of 20 seconds. The interruption in the uvby observations before the peak of the flare corresponds to the time during which we measured Hβ and the moved off the star to measure the sky. The break immediately after the peak corresponds to the time of confusion produced in the observer by the flare itself - time during which the equipment and the identification of the star were checked.

Our observations include the peak of the flare and the sharp rise immediately preceding. However, due to the length of our integrations (20 seconds) detail has been lost. Nevertheless, the mean rates of brightening preceding the peak are at least $0^m.021$/sec, $0^m.013$/sec, $0^m.008$/sec, and $0^m.005$/sec in the filters u, v, b, and y, respectively. According to the criterion of Haro (1968), $0^m.005$/sec, these rates classify G64-34 as a flare star. Also the shape of the lightcurve in Figure 1 is that of a type I flare as defined by Gurzadyan (1980).

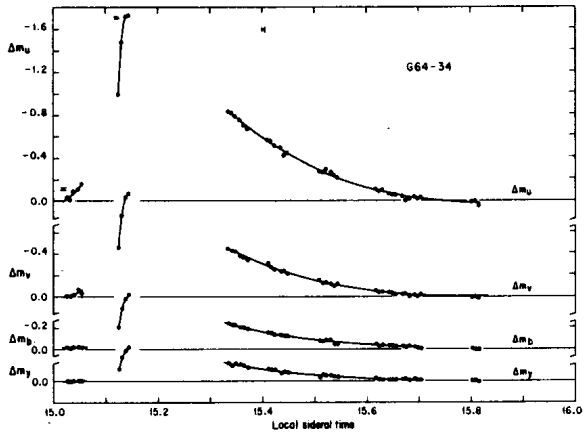

Figure 1.: The observed lightcurves of the flare of G64-34 from the night of 12/13 March 1988. The vertical coordinates are the instrumental magnitudes in u, v, b, and y, and the horizontal coordinate is the local sidereal time (in hours) for the San Pedro Martir observing site.

In Figure 1 it is quite obvious that the flare began in the u band, and perhaps also in the v band, prior to any brightness changes in the b and y bands. There is also marginal evidence that after the flare the star was returning to a brightness level slightly fainter than before the flare. This is clearest for the b band where the brightness levels before and after the flare are well defined. If we assume that the difference in brightness is due strictly to atmospheric extinction, we calculate k_b=0.367 which is unrealistically large for the San Pedro Martir observing site (Schuster, 1982).

For G64-34 the photometric data of Sandage and Kowal (1986) give δ (U-B)= +0.18, a blanketing corrected (B-V) of +1.19, M_V=7.602, and a distance D=75 pc. Using the Lowell and Luyten proper motions and the radial velocity measurement by Fouts and Sandage (1986), Sandage and Fouts (1987) calculate (U, V, W)= =(+65.9 km/sec, -65.2km/sec, +52.9km/sec) and S=106.7km/sec, where (U, V, W) are the usual galactic velocity components and S is the total space motion relative to the Sun. We estimate photometrically a spectral type of K5-K6 for the star (Johnson, 1966). For comparison, if we assume that G64-34 lies on the Population I ZAMS, its B-V=1.01 implies M_V=6.75 (Allen 1973), D=110 pc, (U, V, W)=(+103.0, -92.4, +67.9), S=154.1 km/sec, and a photometrically estimated spectral type of K2-K3. However, the resulting kinematics are not Population I, but they do give us an upper limit for possible velocities of G64-34 in the Galaxy. Another possibility is that G64-34 is a Population II subdwarf.

Then the value B-V=1.01 gives M_V=7.95 (Allen, 1973), D=64 pc, (U, V, W)= =(+54.3, -56.7, +48.2), and S=92.1 km/sec.

The range of kinematic parameters calculated above for G64-34 place it in the velocity space where the old thin disk, thick disk and halo populations overlap. The W component of approximately +50 km/sec means that G64-34 will move the approximately 800 pc above the galactic plane (Eggen, Lynden-Bell, and Sandage, 1962), suggesting that it is a member of the thick disk or halo populations. If the motion of G64-34 is not due to some sort of dynamical expulsion from a cluster or multiple system, then its age must be in the range 2×10^9 to 18×10^9 years, similar to those of stars in the old disk or halo populations. Other fairly old flare stars are known. For example, Wolf 630 is a flare star with an age similar to that of the old disk cluster M67 (Kunkel, 1970; Eggen, 1969). Other flare stars which probably belong to the old disk population are Wolf 359 and 40 Eri C (Kunkel, 1970), but none of these have kinematics as extreme as G64-34. Wolf 630 has (U, V, W)=(-26, -33, +12) (Eggen, 1969).

G64-34 is unusual in another sense. According to the discussion of Gurzadyan (Chapter 1, 1980) most UV Ceti-type (field) flare stars are of spectral class M with absolute visual magnitudes greater than 8.0. Only about 7% belong to the K spectral classes. For G64-34 we have estimated a spectral class of K5-K6 and $M_V \cong 7^m.6$-$8^m.0$, and we observed flare amplitudes of approximately $1^m.73$, $0^m.96$, $0^m.52$, and $0^m.32$ in the u, v, b, and y bands, respectively. According to Gurzadyan (1980), a flare with this amplitude for a field star with $M_V \cong 8.0$ should be very infrequent. Only in fairly young clusters or associations, such as the Pleiades, are flare amplitudes in the ultraviolet greater than $1^m.6$ detected with any frequency for the mid-K spectral types. However, on the Palomar prints we see that G64-34 is not now a member of any cluster or association.

On the night of June 10/11, 1988, we re-observed G64-34 with the same instrument, monitoring it for three and a half hours without detecting any further flare activity. According to Gurzadyan (1980), the average flare frequency for G64-34 should be approximately 1 flare each 4.2 hours, for all flares with $\Delta U > 0^m.1$. More monitoring of this star is strongly encouraged.

In conclusion, on the night of March 12/13, 1988 we observed an unambiguous flare event for the high-velocity star G64-34. The kinematics, photometrically estimated spectral type, and absolute visual magnitude of G64-34 are not typical for a field flare star. The kinematics suggest that the star is a runaway star or that it belongs to the thick disk or halo populations. In the latter case, we conclude that flare activity continues over a significantly large portion of the main-sequence lifetime of a metal-poor late-type star.

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