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FLARES DISCOVERED ON 1RXS J220111+281849

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The star 1RXS J220111+281849 (Voges et al. 1997) = GSC 2215_1629 (Jenkner et al. 1990) = G 188-38 (Giclas et al. 1980) = HIP 108706 (ESA 1997) was found to have significant X-ray emission in a survey by the ROSAT satellite (Bade et al. 1998). It was classified as an M4 star by Reid (1995) with an apparent magnitude of V = 11.99 by Weis (1987), (B−V) = 1.63 (Harrington et al. 1993) and a distance of 8.96 ± .25 pc (ESA 1997). As part of a search for radial velocity variations of nearby K and M dwarfs, Delfosse et al. (1998) measured its $v \sin i$ to be 29.6 km sec^{-1} and observed hydrogen lines to be in emission.

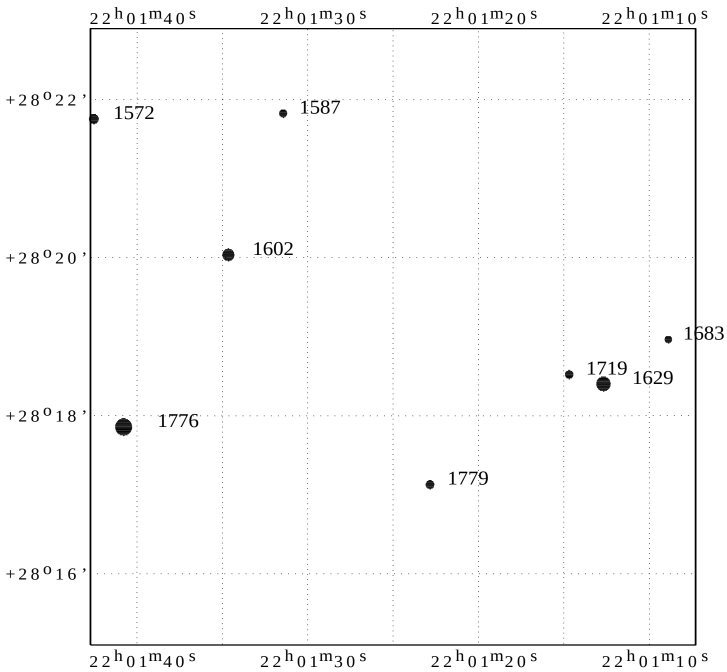

Figure 1. Finder chart labeled with the GSC numbers.

Plotted in Figure 1 is the field of stars observed with the automated 0.5-m telescope and reduced in a fashion identical to that described in Robb et al. (1997). Tabulated in Table 1 are the stars' identification numbers, coordinates (J2000) and magnitudes from the

Table 1: Stars observed in the field of GSC 2215_1629

GSC No.	R.A. J2000	Dec. J2000	GSC Mag.	ΔR Mag.
1629	$22^h01^m13^s$	$+28°18'24''$	11.6	0.307 ± .015
1776	$22^h01^m41^s$	$+28°17'51''$	10.7	-
1602	$22^h01^m35^s$	$+28°20'02''$	12.5	1.780 ± .004
1587	$22^h01^m31^s$	$+28°21'50''$	14.0	3.372 ± .007
1779	$22^h01^m23^s$	$+28°17'08''$	13.8	3.222 ± .003
1719	$22^h01^m15^s$	$+28°18'31''$	13.8	3.145 ± .016
1683	$22^h01^m09^s$	$+28°18'58''$	14.2	3.786 ± .013
1572	$22^h01^m43^s$	$+28°21'45''$	13.3	2.615 ± .005

Hubble Space Telescope Guide Star Catalog (GSC) (Jenkner et al. 1990). Differential ΔR magnitudes are calculated in the sense of the target star minus GSC 2215_1776. Brightness variations during a night were measured by the standard deviation of the differential magnitudes, which ranged from $0.^m005$ for bright stars on a good night to $0.^m050$ for the faint stars on poor nights.

The run mean of the thirteen nightly means and their standard deviation, which is a measure of the night to night variations, are given in Table 1 as ΔR and its uncertainty. The high precision of these data can be seen from the standard deviation of the ΔR of GSC 2215_1779 minus GSC 2215_1776, which is $0.^m003$ and shows that these two stars are constant at this level of precision. The fainter stars have the expected larger standard deviation. The star GSC 2215_1629 had obvious flares of up to $0.^m3$ during four nights and also slight changes of about $0.^m020$ on an hourly time scale.

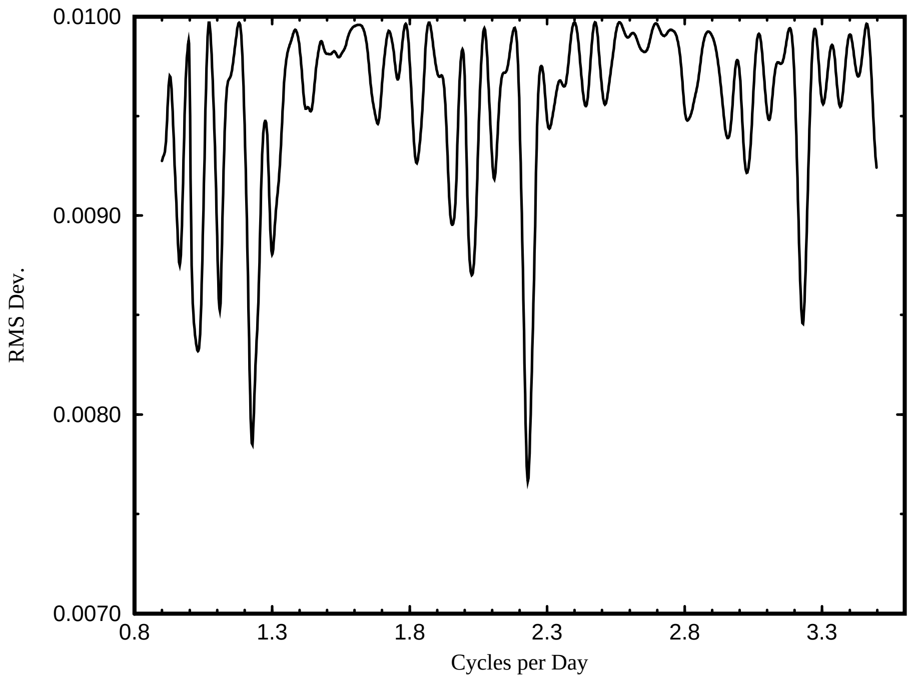

Figure 2. Periodogram for 1RXS J220111+281849 for 1998

The four nights which showed flares were excluded from the search for periodicity and the other nine nights were fit with a single sine curve of various frequencies. In Figure 2 we have plotted the RMS deviation of a point from a sine curve as a function of period.

There is little ambiguity in the determination of the photometric period of GSC 2215_1629, which gives the ephemeris:

$$\mathrm{HJD\ of\ Maxima} = 2451053.386(50) + 0\overset{\mathrm{d}}{.}448(5) \times E,$$

where the uncertainties in the final digits are given in brackets.

The differential (GSC 2215_1629−GSC 2215_1776) R magnitudes of the nine nights with no flares, phased at this period, are plotted in Figure 3 with different symbols for each of the nights. We suspect that this variation is due to rotation of an asymmetry in the distribution of spots into and out of our view. Since the star may rotate differentially and the spot asymmetry may change, we do not expect the rotation period of the star to be precisely this value. Combining our period with the maximum rotation period, $P/\sin i$ of Delfosse et al. (1998) gives the inclination of $58 \pm 4°$ for the axis of rotation, assuming a radius of 0.3 $R_\odot$, where the quoted uncertainty does not include the contribution from differential rotation.

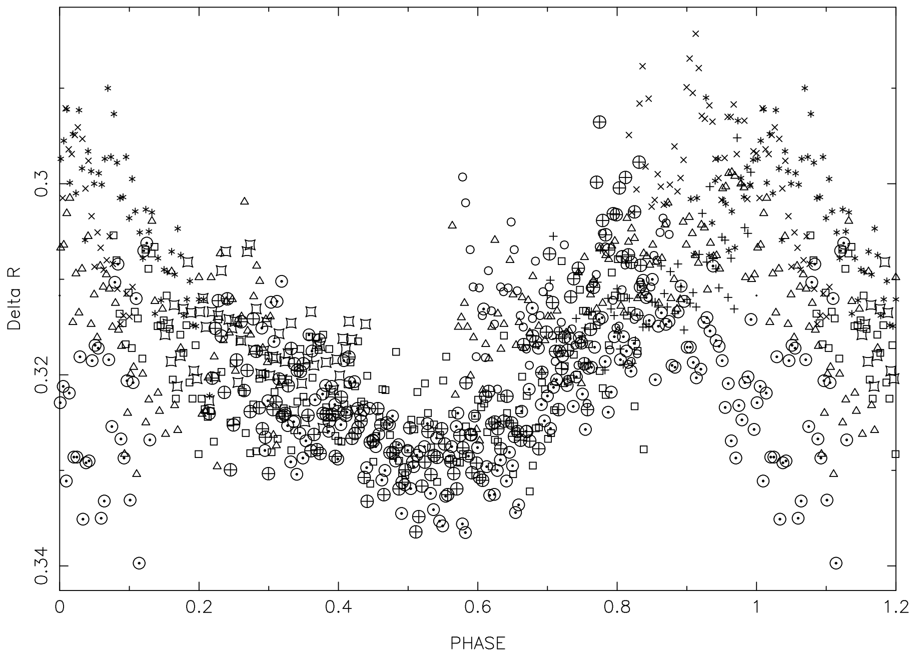

Figure 3. R band light curve of 1RXS J220111+281849 for 1998

During four nights we observed flares of large amplitude which are plotted in Figure 4. The Heliocentric Julian Dates (−2451000) of the onset of the flares, were 55.7223, 60.8024, 60.9995, 70.7525, 76.7180, and 76.9140, where the time between individual data points is about 0.0020 days. On two of the nights we see a pair of flares separated in time by 0.1960 and 0.1971 days, which are identical considering the spacing of the data.

The probability of two pairs of flares having the same spacing in time as chosen from our 1452 data points is extremely small and hints at a possible periodicity. The time spacing implies that there are either two regions on opposite sides of the star which flared or one region which flared near one limb of the star and then the other. A search for periods which superimpose the flares in phase, yields a good fit at the period of 0.4421 days, which is intriguingly close to the photometric period, but there were many other periods with residuals nearly as small. Obviously more data is needed to give any confidence in a possible periodicity of the flaring activity. We eagerly await next year to confirm or disprove this periodicity and urge observers to contribute to an international campaign by contacting the authors.

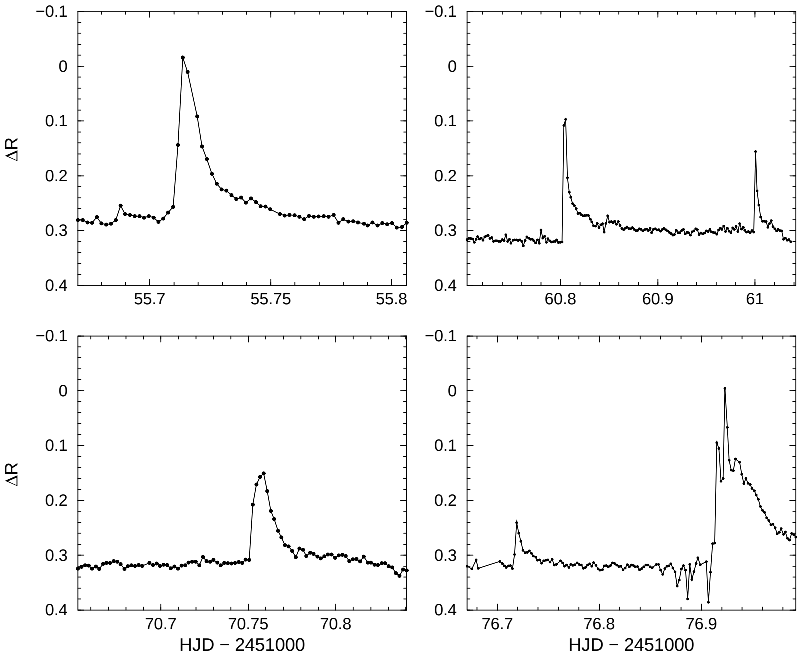

Figure 4. Differential R measurements of 1RXS J220111+281849 for the nights with flares

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