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HV 2554 AND THE SUPERSOFT X-RAY SOURCE RX J0527.8–6954[1]

The discovery of the supersoft X-ray source RX J0527.8–6954 during the *ROSAT* first light observation (Trümper *et al.* 1991) of the Large Magellanic Cloud (LMC) in June 1990 has directed some attention to the optical variable HV 2554 because its location is within the X-ray error circle of RX J0527.8–6954 (Trümper *et al.* 1991, Greiner *et al.* 1991). Later ROSAT observations improved the X-ray position resulting in a larger offset to HV 2554 (Cowley *et al.* 1993, Greiner *et al.* 1996a,b). However, it also became clear that there are no exact coordinates available (no SIMBAD entry) for HV 2554. To our knowledge the only finding chart available for HV 2554 is the Large Magellanic Cloud atlas by Hodge & Wright (1967) (see Fig. 1), but unfortunately the scale is too poor and the variable itself invisible. While only a summary of the variability of HV 2554 is published in form of table entries in Shapley & Mohr (1940) (based on the investigation of only 12 plates) and Shapley & McKibben Nail (1955), the detailed notes of the Gaposchkins (C.H. Payne-Gaposchkin and S. Gaposchkin) on the brightness estimates of HV 2554 on 380 plates (taken between 1896 and 1954) of mainly the A series are unpublished.

Given these facts we went back to the original plates and re-identified HV 2554. From the unpublished individual brightness estimates (recently archived by D.L. Welch and electronically available on http://www.physics.mcmaster.ca/HCO/) we selected four plates: two with HV 2554 being brightest and two plates with it being in a faint state. A comparison of the brightest/faintest plate pairs quickly revealed a clearly variable object with an amplitude consistent with the value of $\Delta m \sim 1.6$ mag (Shapley & McKibben Nail 1955). Our independent relative brightness estimates on nearly 30 further plates are in good agreement to those of the Gaposchkins and thus confirm the correctness of our re-identification. The astrometry on plates showing HV 2554 in the bright state is overplotted on a CCD frame taken in March 1995 (small circle on Fig. 2) and demonstrates that its position is within the $5''$ X-ray error circle of RX J0527.8–6954.

These findings provided the motivation to determine the pattern of optical variability of HV 2554 over the last six years during which RX J0527.8–6954 was found to gradually decline in X-ray intensity (Greiner *et al.* 1996a,b). For this purpose, we investigated about 140 blue plates out of the 447 plates (210 blue, 230 red) taken between October 1990 and January 1995 within the EROS project for the search of microlensing events of the LMC (Aubourg *et al.* 1993). Two different emulsions were used in the blue passband (with filter GG385): IIaO during 1990–1993, and the emulsion IIIaF during Oct. 1993–1995. While plates of both emulsion types are generally more sensitive than the Harvard plates, the IIIaF emulsion even provides a spatial resolution below $2''$, thus reaching in best cases a quality comparable to the CCD image shown in Fig. 2 (seeing of $0\overset{''}{.}9$). As a consequence, in most cases several or even all of the at least 6 objects within the astrometric error circle

[1]PARTLY BASED ON OBSERVATIONS WITH THE ESO 2.2 M TELESCOPE AT LA SILLA/CHILE (MPI TIME).

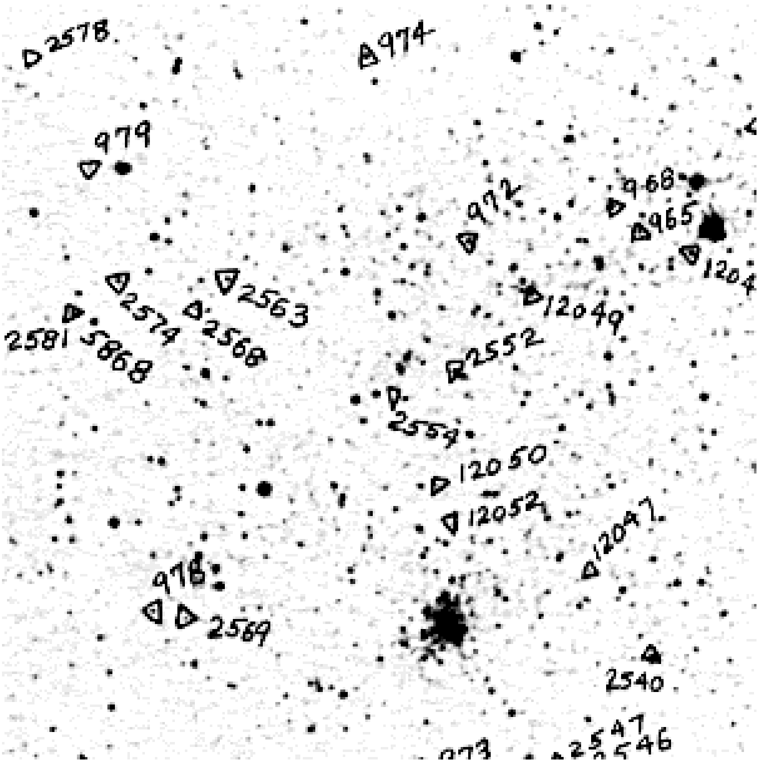

Figure 1: A 13.′5*13.′5 area around HV 2554 (center) reproduced from the Hodge & Wright (1967) atlas of the LMC. The variable is located inside the triangle above the "2554" mark. North is at the top and East to the left.

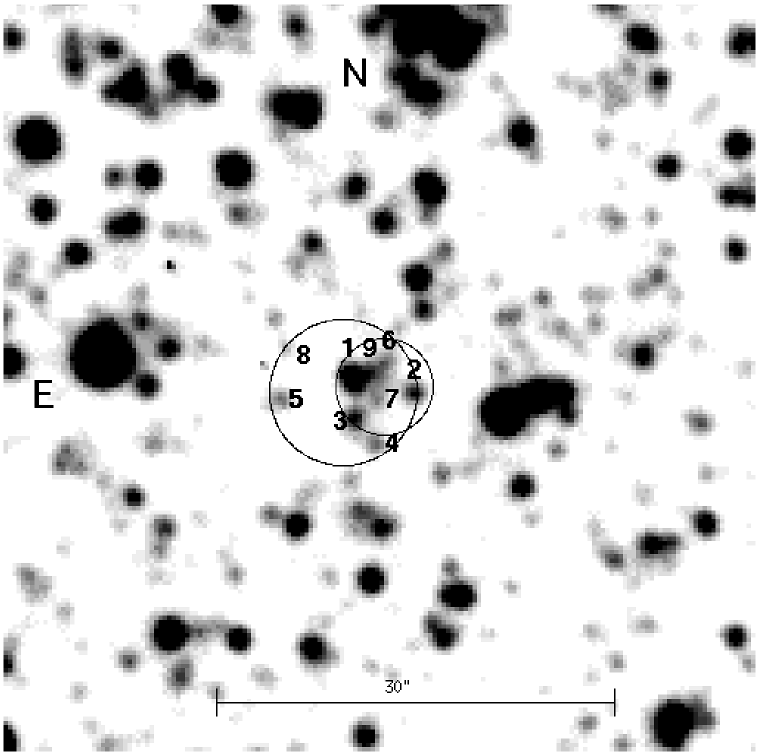

Figure 2: The 5″ X-ray error radius (large circle) of RX J0527.8–6954 overplotted on a 10 min B image taken on March 25, 1995 with the ESO 2.2 m telescope at La Silla/Chile. The small circle denotes the best-fit astrometric position of HV 2554 as determined from plate A 14531 of the Harvard plate collection. Numbers denote all resolved objects within the X-ray error circle (large circle, Greiner *et al.* 1996a).

of HV 2554 are resolved and detectable on these EROS project plates. In addition to these plates, we have investigated single plates taken for other purposes in the years 1975, 1977, 1978, 1987 and 1989. The surprising result of our analysis of all the investigated plates was the fact that we did not find any variable object within or around the astrometric position of HV 2554.

The non-variability of any of these objects on the EROS Schmidt plates as opposed to the apparent variability on the Harvard plates can be due to several reasons:

1. *The re-identification of HV 2554 is wrong* while the original measurements are of a different object. We have carefully checked this possibility, but can definitely exclude it. There is no other star of the given brightness around the position marked on the Hodge & Wright (1967) atleas, and in addition the variability pattern found on the plates coincides with that of the unpublished notes of the Gaposchkins.
2. *HV 2554 has ceased to be variable* in the two decades between the last Harvard plates (1954) and the first EROS project plates (1990) (with the few other, individual plates it would be even before 1977). Though this would be a rare circumstance, it cannot be excluded.
3. *HV 2554 is not intrinsically variable on the Harvard plates.* Instead, the combination of variable seeing and different limiting magnitudes of the plates result in a different size of the image of the several overlapping objects and thus counterfeits a variability. This reasoning implies a clear prediction, namely that HV 2554 appears bright on plates with better than average seeing and sensitivity, so that objects 2, 3 and 6 (and probably also 4) contribute to the size of the merged image while on plates with bad seeing and sensitivity only object 1 is imaged, thus resulting in a considerably smaller size on the plate. A re-investigation of the Harvard plates has indeed confirmed this relation between the brightness of HV 2554 and the plate quality.

We therefore conclude that though variations are seen at first glance on the Harvard plates, a careful look including a consideration of the effects of different seeing, different fog level and limiting magnitude shows that variations of HV 2554 are marginal at best. A hint of support comes from the fact that the measurements on the unpublished notes from the Gaposchkins were crossed out which usually means that they did not consider the object to be variable in the end. We would like to mention, however, that it is not possible to exclude definitely intrinsic optical variability of HV 2554.

Given the large amplitude of the X-ray decline of RX J0527.8–6954 over the last six years (a factor of 50), one is inclined to expect a correlated (either positive or negative) variability of its optical emission. The lack of any obvious optical variability of objects 1 through 9 in Fig. 2 (though somewhat uncertain for the faint objects 6 through 9) suggests that none of these is the optical counterpart of RX J0527.8–6954. Sensitive optical observations (imaging and spectroscopy) at sub-arcsecond resolution are certainly required to identify RX J0527.8–6954.

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