PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC
89:139–140, April 1977

A PROBABLE BINARY CENTRAL STAR IN THE PLANETARY NEBULA NGC 6853

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Received 1976 November 12

Improved proper motions of the central star and its faint companion in the planetary nebula NGC 6853 indicate that this is very probably a physical pair. The faint companion is yellow or red in color and probably lies on the main sequence.

Key words: planetary nebulae — binary stars

A few years ago a list of possible visual binary central stars in planetary nebulae was published (Cudworth 1973, Paper I). Besides the well-known case of NGC 246 (see e.g., Minkowski 1965), the pair in NGC 6853 (M27) appeared most likely to be physical on the basis of the proper motions then available. The basic data for this latter pair were given as $m_{pv} \approx 14^m0$, 17.0; $\rho = 6''.5$; $\theta = 214°$. At an approximate distance from earth of 380 pc (Cudworth 1974) the minimum separation of the components is nearly 2500 AU. This paper reports an improved proper-motion determination which strengthens the case for physical association of this pair.

The proper motions listed in Paper I were based on four plates taken with the Lick 36-inch (91-cm) refractor (scale = $11''.72$ mm^{-1}) in the period 1962.6 to 1972.5. Four additional plates have now been taken at epoch 1976.8 with the Yerkes 40-inch (1-m) refractor (scale = $10''.65$ mm^{-1}) and have been combined with the Lick plates. Trial solutions with the present plate material confirmed the finding of Jones (1971) that Lick and Yerkes refractor plates may be combined using only linear terms in the plate constants. The reference frame consisted of the same 20 stars as before (Paper I; Cudworth 1974). Unlike the earlier solution, however, the central overlap method has been used in the present reductions. This has resulted in very significant improvements in the plate constant solutions since reference-star proper motions can be determined and allowed for.

Because of the very blue color of the central star, one must consider the effect of differential atmospheric refraction upon the positions of the central star and the reference stars (assumed mean $\langle B-V \rangle \approx 0^m7$). The passband of the Lick plates was defined by the OG4 filter and 103a-G emulsion, while the Yerkes plates were taken on the same emulsion but through GG14 (three plates) or OG1 (one plate) filters. In all cases, the color-correction constants used in the respective parallax programs (Vasilevskis 1975; van Altena and Moseley 1975) have been applied to the measures of the central star, but not to those of the companion. Since all plates were taken at hour angles $\leqq 2^h$, these corrections were never greater than 1.0 micron.

When comparing stars differing by three magnitudes, one must be very careful of magnitude-dependent systematic errors. All plates were measured direct and reversed to eliminate any such effects introduced by the measuring process. (The measuring machines used were the Lick Automatic measuring engine and the Yerkes Ridell measuring engine.) Magnitude terms in the plate constants were found to be unnecessary on all but one plate. Any remaining magnitude-dependent errors should therefore be very small. The resulting relative proper motions and their standard errors are listed in the upper section of Table I.

A number of unfiltered blue plates taken with reflecting telescopes are also available to the author. Comparison of these with the refractor plates indicates that the companion is yellow or red in color but a quantitative determination of color index is not possible from this material due to severe nebular contamination of the image of the companion.

One of these reflector plates was taken in 1931 at the Newtonian focus of the Mount Wilson 60-inch (1.5-m) reflector. This appears to be the plate reproduced by Ross (1933). (The companion was lost in the reproduction.) An attempt has been made to match this with two second epoch plates from the *f*/8 Ritchey-Chrétien focus of the Yerkes 41-inch (1-m) reflector, which yields a very similar scale ($\sim 25''$ mm^{-1}). All of these plates were taken at small hour angles, but the differing latitude and elevation of the observatories, as well as the unknown transmission of the Ross corrector used in 1931 and possible differences in emulsion characteristics, will lead to color effects which can be determined only approximately. A reference frame of 16 stars within $5'$ of plate center was measured on a manual measuring engine and it was found that the plates could be combined using only linear plate

TABLE I

RELATIVE PROPER MOTIONS

Telescopes	Star	μ_α ("/century)	μ_δ
Refractors	central	1.3 ± 0.1	0.7 ± 0.2
	companion	1.7 ± 0.2	0.5 ± 0.3
Reflectors	central	1.3 ± 0.4	1.0 ± 0.4
	companion	2.5± 0.7	1.0 ± 0.7

constants. Unfortunately, the resulting proper motions have errors two to three times greater than those from the refractor plates. This is due to the severe contamination of the companion by nebulosity as well as the poorer scale, smaller number of plates, and possibly-inadequate color correction. To within these limits, however, the motions of the central star and its companion are probably common, as can be seen in Table I.

Taken together, this evidence indicates that the central star of NGC 6853 is very probably a wide physical binary. The faint companion is yellow or red in color. At the distance quoted above the central star has $M_v \sim +6$ magnitudes and the companion $M_v \sim +9$ magnitudes. The former is rather faint, but probably reasonable for a large (0.3 pc radius), and thus presumably old, planetary. The latter, combined with the estimated color, is consistent with the companion being a late-type main-sequence star. Spectroscopy and photometry of the companion should be attempted in order to determine one of the few reliable distances to an individual planetary nebula.

This research has been partially supported by the National Science Foundation.

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