them from compact extragalactic sources with similar radio spectra. For example neither the faintest SNR found in the Clouds nor the most luminous unresolved remnant there would have been identified as a galactic SNR in existing surveys if at a distance of 20 kpc in the disc of the Galaxy.

A search for new galactic remnants of small diameter has begun, making use of the continuing MOST survey of the Galactic plane. Radio sources for checking have been taken from the 408 MHz Molonglo catalogue of unresolved sources close to the plane (Clark & Crawford 1974), and the 5 GHz Parkes survey (Haynes, Caswell & Simons 1979) has been used to provisionally reject sources with an unlikely spectrum. Also, sources of low latitude in the Molonglo Reference Catalogue (Large *et al.* 1981), which are noted as E (extended) or C (complex), are being mapped as part of a general program. Some of these may also be small diameter SNRs of low luminosity.

Several of the sources mapped so far have a morphology reminiscent of SNRs. However their radio recombination line strength (Haynes, private communication) is consistent with that for HII regions except for 1635-473 (G337.4-0.4). This source (Fig. 2) is a likely supernova remnant with the following properties:

Position (1950.0), $16^h\ 35^m\ 13^s$: $-47°\ 20'\ 50''$
Flux Density, $S_{408} = 2.3$ Jy; $S_{843} = 1.53$ Jy; $\alpha = -0.6$
Effective Angular Diameter, $\theta = 1.5$ arcmin
Mean Surface Brightness $\Sigma_{843} = 10 \times 10^{-20}$ W m^{-2} Hz^{-1} sr^{-1}

Many authors have presented formulae for the distance of an SNR as a function of its flux density and angular size. However the large scatter in the luminosity of identified remnants in the Clouds shows that such distance estimates for a single source are very uncertain. G337.4-0.4 has been compared with Cloud remnants of similar surface brightness

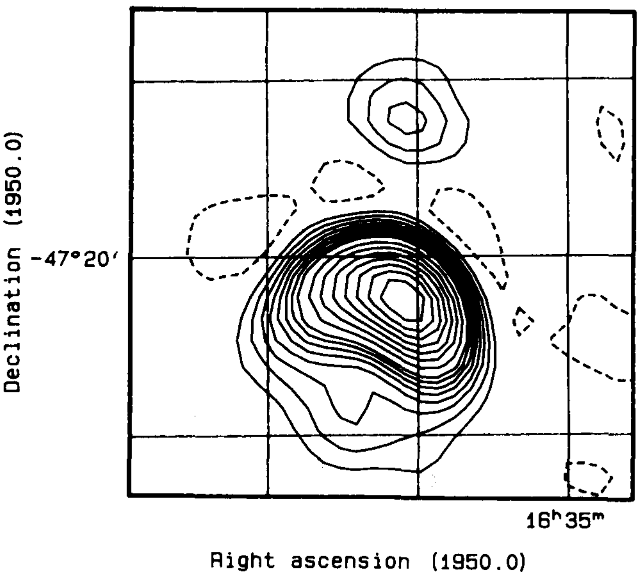

Figure 2 The galactic SNR G337.4-0.4. The declination grid spacing is 2′ and the RA grid 10^s. Contour levels in mJy/beam are as follows:
−20 20 40 60 80 100 120 140 160
200 240 280 320 360 400 440

assumed to be at 55 (LMC) and 63 (SMC) kpc; the geometric mean of the resulting distances is 32 kpc but with a one-sigma uncertainty factor of 1.5 either way. The corresponding one-sigma ranges for diameter are 9.6-21 pc, for luminosity (843 MHz) 8.8-42 $\times 10^{16}$ W Hz^{-1}, for galacto-centric distance ($R_0 = 10$ kpc) 13-39 kpc and for height above the Galactic plane 155-335 pc. These results are consistent with a typical SNR lying in the outer regions of the Galaxy.

The search for small diameter galactic SNRs is a long term project of low priority and quick results cannot be expected. This early discovery of a probable remnant is gratifying.

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The RS CVn Type Star PZ Tel

J. L. Innis, D. W. Coates, and K. Thompson,
Department of Physics, Monash University, Clayton, Victoria, 3168

Abstract

We present broadband photoelectric light curves for the RS CVn type star PZ Telescopium for 1980, 1982 and 1983. The photometric period is about 0.943 days. The V light curve shows radical changes in form and range over a few months, and may be continuously variable. B and V data were obtained in 1982 and 1983. In 1982 no (B-V) change with phase was detected.

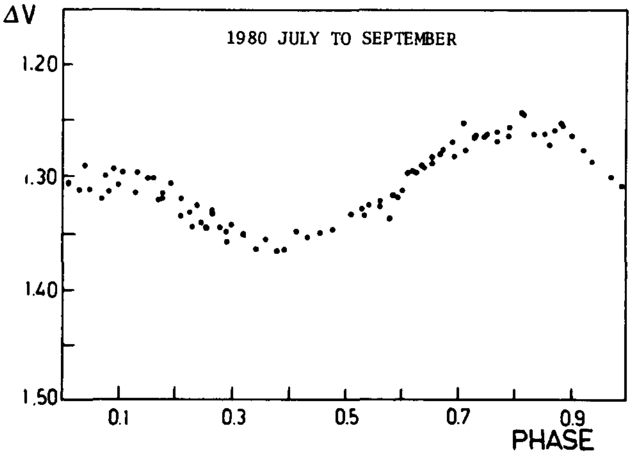

Figure 1. Light curve of PZ Tel in 1980.

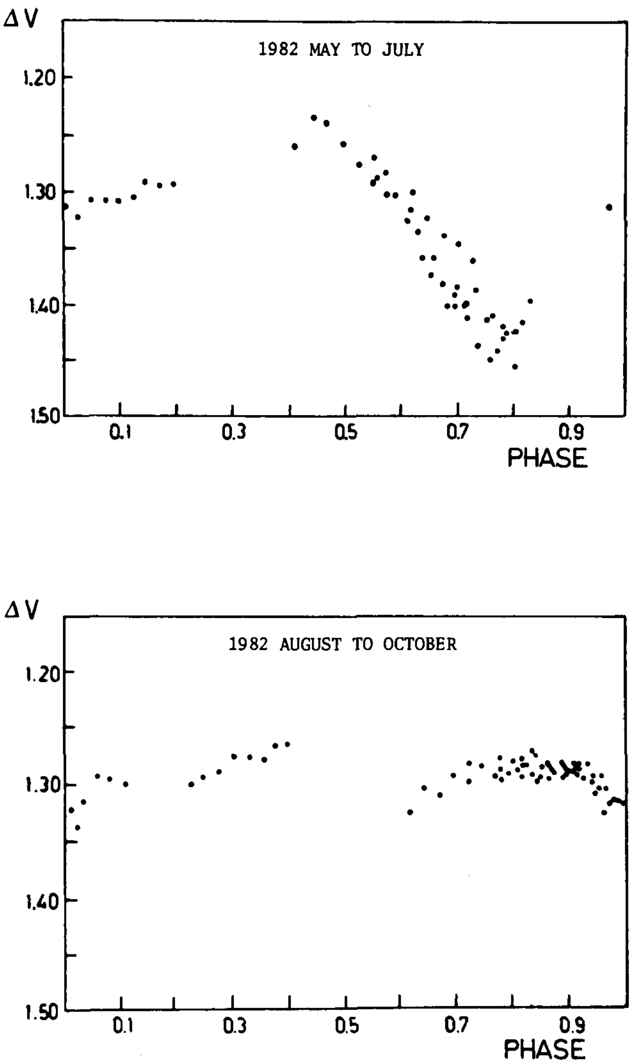

Figure 2. Light curves of PZ Tel in 1982.

However, in the first part of the 1983 observing season, a (B-V) change of around 0.02 magnitude was found. Also at this time, maximum light was some 0.05 magnitude above that measured previously. Our preliminary spectroscopic data obtained in 1983 indicate that PZ Tel is a double lined binary whose components are of approximately equal luminosities, but this is yet to be confirmed. We suggest that the photometric variations are due to the presence of large cooler starspots on the photosphere of one or both components, as seems to be the case for related systems. The rapid changes in the observed light curve imply equally rapid changes in the distribution of the starspots, and make this an interesting object for further study.

The RS CVn Stars

These stars have been the subject of much research since the mid 1970's. The characteristics of the group were defined by Hall (1976):

1. Detached binary stars with a period between one day and two weeks.
2. The components are typically F-G V and KO IV.
3. The cooler secondary shows strong Ca II H and K emission.

The light curve often exhibits a large (~0.2 magnitude) photometric wave, which can vary in amplitude and drift in phase relative to the system's orbital period. It is generally accepted that this photometric wave is due to large starspots on the surface of the secondary. These spots seem to be around 1000 K cooler than the surrounding photosphere, and cover up to 20% of the visible hemisphere.

Over the last few years it has been found that many stars show similar activitiy (starspots), and that Hall's definition does not encompass all types, although it may fairly rigidly define a subclass.

PZ Telescopium (HD 174429)

This star was included on a list of southern RS CVn candidates on the basis of its strong Ca II H and K emission. We have obtained photometric data on PZ Tel using the 0.4 m telescope of the Monash Observatory, and with the 0.4 and 0.6 m ANU telescopes at Siding Spring Observatory. All observations were made differentially, mainly relative to HD 176557 and HD 176664 and have been transformed to the standard UBV system. The measured difference in B and V between comparison stars was constant to better than ±0.01 magnitude over the three seasons of observations (Innis *et al.* 1983).

The light curves in Figures 1 and 3 show V(PZ Tel) – V(HD 176557). All the data are plotted using the epoch HJD 244444.000 and a period 0.943 days. All of the light curves, except that for the latter part of 1983, have appeared in Coates *et al.* (1980), Coates *et al.* (1982) and Innis *et al.* (1983). The light curves clearly show large changes in shape and range even over a few months.

The photometric behaviour is summarised in Table 1.

If, as seems likely, starspots are the cause of the photometric variations, then the rate of spot redistribution, or spot formation and decay, must be amongst the highest of any RS CVn type star known to date.

(B-V) Data

In 1982 and 1983 (B-V) data were obtained. We found that (B-V) was constant within observational error at +0.77±0.01 for the whole of the 1982 season. These data are plotted in Figure 4. In the first half of the 1983 season, however, a color change of some 0.02 magnitude was found (Figure 5). At this time maximum light was about 0.05 magnitude above that measured previously.

In the latter part of the 1983 season, when the range in V was only 0.08 magnitude, the (B-V) value ranged from 0.75 to 0.80 in a manner apparently unrelated to the V light variations (Figure 6). Calculations show that a well defined relationship

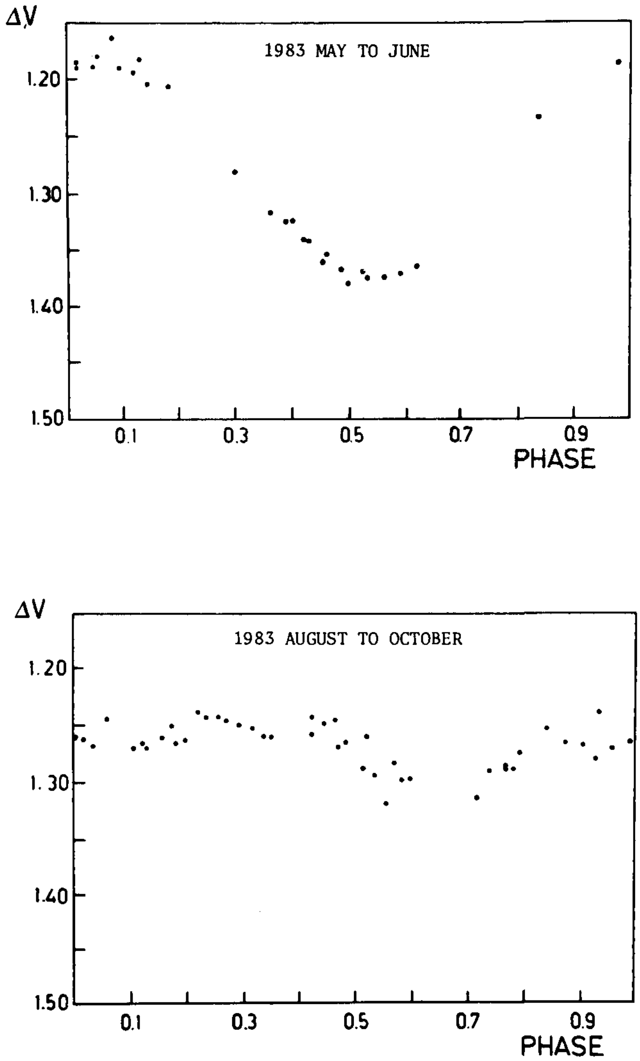

Figure 3. Light curves of PZ Tel in 1983.

Table 1

Photometric Behaviour of PZ Tel

Epoch	1980 July-Sept	1982 May-July	1982 Aug-Oct	1983 May-June	1983 Aug-Oct
V_{max}	8.42	8.41	8.44	8.36	8.42
V_{min}	8.54	8.63	8.51	8.56	8.50
Range	0.12	0.22	0.07	0.20	0.08
B-V	–	0.77	0.77	0.77–0.79	0.75–0.80

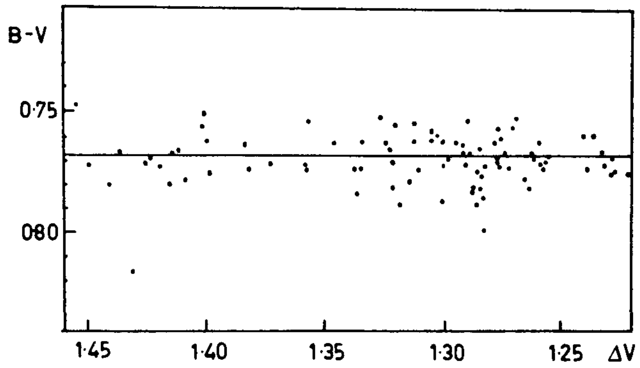

Figure 4. B-V versus ΔV for 1982 May to October.

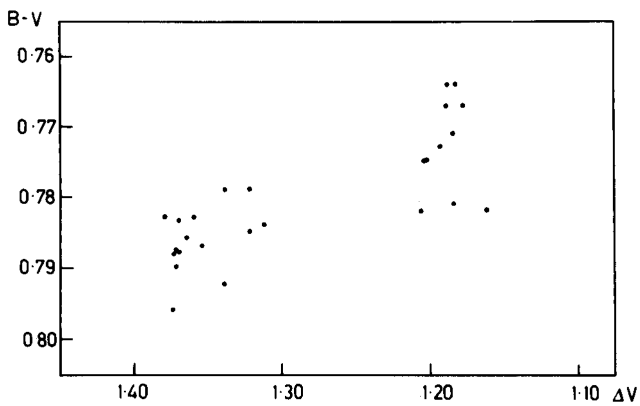

Figure 5. B-V versus ΔV for 1983 May to June.

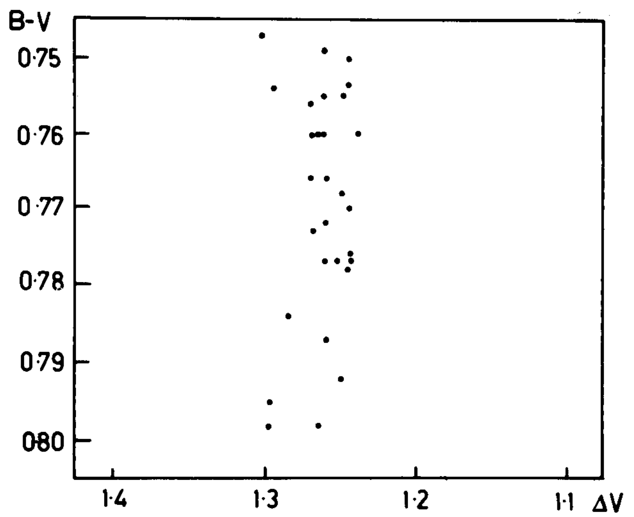

Figure 6. B-V versus ΔV for 1983 August to October.

should exist between (B-V) and V for stars with spots of a given temperature. Our data, which show that a dependency of (B-V) on V is sometimes present and sometimes not, suggest that the temperature of the spots could change with time.

Discussion

The lack of a flat-topped maximum in any of the five V light curves means that the starspots are never completely out of view, and that we have probably not measured the star's true unspotted brightness. This presents problems when trying to model the starspots using multicolour photometry, as the properties of the unspotted star must be known in order to determine the spot temperatures and areas unambiguously. (Vogt 1981).

The data for 1982 May-July (Figure 2) show fairly large scatter compared with the other light curves. The deep minimum ($\Delta V \sim 1.45$) at phase ~ 0.8 in particular is poorly defined. Most of the data at this phase were obtained on four successive nights at Siding Spring Observatory. We believe the scatter is largely due to real changes in the star over these four days.

Data obtained near this phase one month later (same figure) are some 0.05 magnitude brighter. In 1982 September, no trace of the minimum at this phase is apparent (Figure 2). This suggests that the spot or spot group causing this variation must have dissipated in less than four months, or around 100 photometric periods. However, as no observations were obtained earlier in the season than 1982 May, we do not know how long the spot persisted prior to its disappearance.

We note that at times the light curve is fairly stable (1980 July to September, Figure 1), and the star may experience alternative active and quiescent phases.

At present we cannot unambiguously relate these observations to quantities such as spot lifetimes or total numbers. However, evidence for a possible spot cycle on this star, presumably related to total spot numbers, is discussed below.

The short period and high level of activity of PZ Tel are consistent with the 'period-activity connection' (e.g., Walter 1981), where for a given spectral type, the faster the star rotates the higher the degree of activity. Similarly, for a given rotation rate, the later the spectral type the greater the activity. This is presumably related to the depth of the convective envelope of the star.

We draw attention to an apparent pattern in the variation of the light curves of PZ Tel, in that the range in V for two of the observing seasons seems to show an approximately six month (or possibly twelve month) cycle. The range in V at the start of the season (~ 0.2 magnitude) is about twice that found at the end (~ 0.1). Rucinski (1983) has reported a similar periodicity in the V light curve of HD 36705 (which also shows strong Ca II emission). This periodicity may be analogous to the eleven year solar activity cycle. However, PZ Tel and HD 36705 are different in that HD 36705 appears to be a rapidly rotating single star (Collier 1982), while PZ Tel is probably a binary. This is based on our spectroscopic data obtained in May and August 1983 using the 1.88 and 1.0 m ANU telescopes. Spectra of PZ Tel both in the blue and red suggest that it is a double lined binary of approximately equal components, but this needs confirmation.

We plan to continue photometry and spectroscopy of this active short period star in an endeavour to model its changing spot distributions.

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Evolutionary Calculations for Planetary Nebula Nuclei with Continuing Mass Loss and Realistic Starting Conditions

D. J. Faulkner and P. R. Wood, *Mount Stromlo and Siding Spring Observatories, Australian National University*

Introduction

The mechanism by which planetary nebula (PN) shells are ejected is still subject to considerable uncertainty. It is generally assumed that the precursors of these objects are low mass ($M < 5$ $M_\odot$) asymptotic giant branch (AGB) stars, and that the nucleus of a planetary nebula (NPN) is undergoing a final gravitational contraction to the white dwarf state. The shell consists of some or all of the remaining unburnt (though not necessarily uncontaminated), hydrogen-rich material out of which the star was originally formed.

It has long been known that stars on the AGB are subject to mass loss by stellar winds (Deutsch 1960), and more recent evidence indicates that the mass loss rate due to these winds increases towards the tip of the branch (Knapp *et al.* 1982); the