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# RECONNAISSANCE OF SUSPECTED OLD NOVAE

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## ABSTRACT

Several of the "blank fields" in the novae atlas by Duerbeck were imaged at the WIYN 3.5 m telescope during technical engineering and commissioning activities in 1994–1995. Several old novae have been recovered utilizing CCD photometry. Multiobject spectroscopy with the Hydra/MOS instrumentation at WIYN was also used on random stars in the fields to search for a cataclysmic variable. The old novae candidates identified include SV Ari, V465 Cyg, SS LMi, V2104 Oph, GR Ori, V529 Ori, UW Per, and UW Tri.

*Key words:* novae, cataclysmic variables

## 1. INTRODUCTION

Until the novae atlas of Duerbeck (1987), observation of classical novae was plagued by the dearth of large-scale, faint-object finding charts and accurate coordinates. This paper is intended to supplement the Duerbeck atlas by providing finding charts and accurate coordinates for some of the old novae whose finding charts are ambiguous or whose existence is uncertain.

Nova hibernation theory (Shara et al. 1986) predicts that mass transfer diminishes and/or stops over the millennia between nova outbursts, inferring an age-luminosity relation. Therefore, it is important to recover as many of the old novae as possible (the older, the better) to compare observations with theory.

The WIYN 3.5 m telescope at Kitt Peak, Arizona, began technical and engineering operations in 1994. During shared-risk observing and testing of the imaging instrumentation, we initiated a survey of "blank fields" in the novae atlas of Duerbeck (1987). Many of these old novae are of questionable existence or are so faint in quiescence that they have remained unstudied since their outburst. Some old novae candidates were recovered using photometry, and follow-up spectroscopic observations for the brighter candidates was initiated. For fields in which no immediately obvious candidate was revealed, multiobject spectroscopy was used on as many stars in the field near the position of the suspected nova as could be assigned by Hydra for the MOS. This multiobject spectroscopy capability at WIYN allowed many of the stars in the field to be exposed simultaneously to search for emission-line objects (presumably the cataclysmic variable).

## 2. WIYN OLD NOVAE OBSERVATIONS

Observations took place during 1994–1995 under a variety of conditions as the WIYN telescope system matured. In general, exposures were taken in an unguided mode with exposures of 3–5 minutes with an STIS 1024 × 1024 CCD containing 21 $\mu$m pixels. Astrometry was obtained by creating a plate solution for the WIYN images from the Digitized Sky Survey using stars in common that are in the *Hubble Space Telescope* (*HST*) guide star's reference frame. Table 1 lists the positions of some of the old-nova identifications in this survey. Finding charts are provided as Figures 1–5, 7, 10, and 11. North is at the top and east is to the left on all charts. A scale is indicated for each. The criteria used to establish the preliminary nova identification in each field were (1) positional coincidence between Duerbeck (1987) coordinates and astrometry from WIYN images, (2) photometric variability for stars with multiple observation epochs, (3) color information for stars with both *B* and *V* observations, and (4) stars with emission-line spectra for fields with multiple-object spectroscopy. Table 2 lists the magnitudes obtained for these stars, along with the applicable criteria in each case used to identify the nova candidate. The recovery of these old novae should be considered provisional until more exhaustive spectroscopic confirmation is obtained. The coordinates and finding charts presented here will facilitate this.

Table 3 lists the old novae fields for which no obvious candidate was found (down to our limiting magnitude) and the number of stars for which spectra were obtained in each field. In general, the optical spectral fibers assigned were restricted to an area 20′ in radius around the coordinates given in Duerbeck (1987). Any assigned fibers could also be no closer than 30″ (WIYN/Hydra limit). A list of specific coordinate assignments within each field can be provided upon request.

### 2.1. *SV Ari* (*Nova Ari 1905*)

Duerbeck (1987) reports that M. Wolf & G. Wolf discovered this old nova on Heidelberg plates on 1905 November 6 and that they reported it to have brightened from 22 to 12 $m_{pg}$, but their originally reported position appeared to be in error when compared with an object at the limit of the POSS. It has remained unstudied since the time of its outburst. The WIYN image used to create its finding chart is in Figure 1, which found it at a *B* magnitude of 22.1.

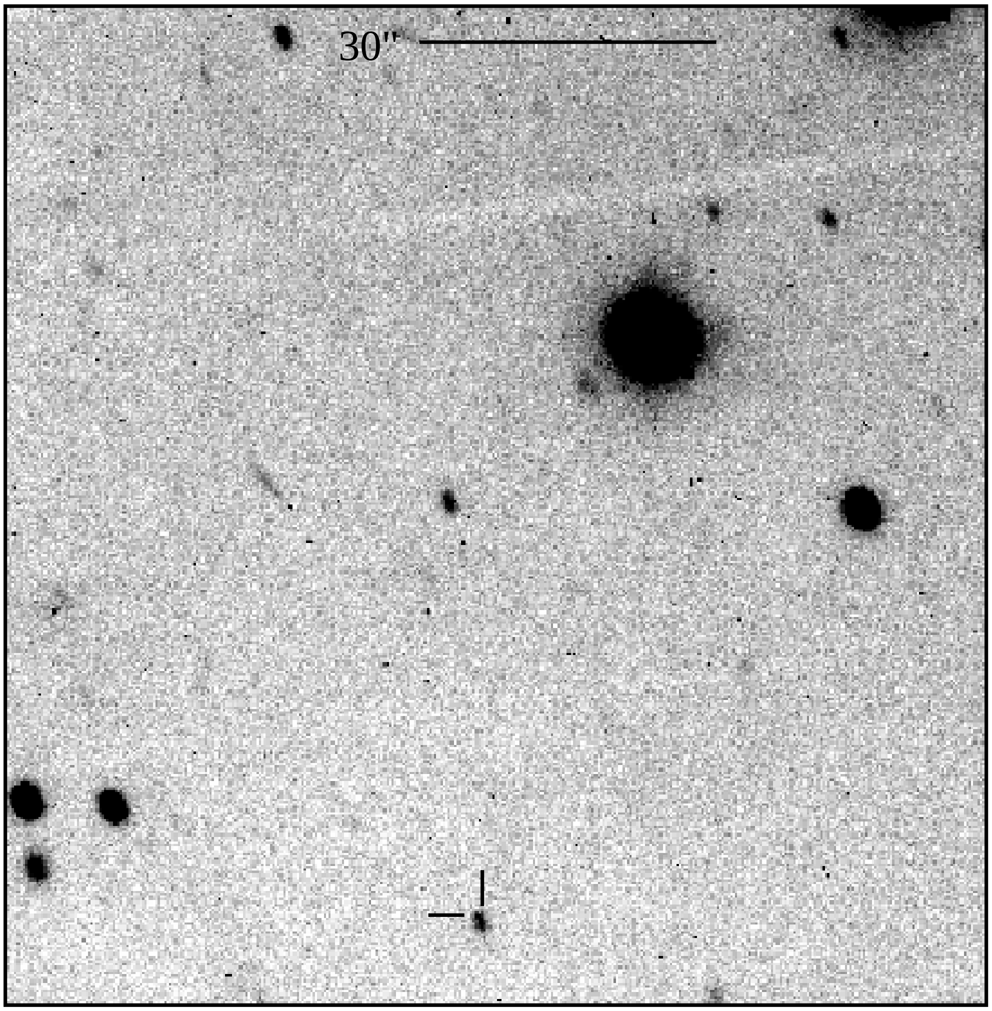


FIG. 1.—SV Ari finding chart. North is at the top and east to the left in this *B*-band exposure. Elongated images are due to occasional tracking problems during telescope commissioning.

### 2.2. *V465 Cyg* (*Nova Cyg 1948*)

According to Duerbeck (1987), V465 Cygni was discovered by B. S. Whitney on 1948 June 2, as a 10th magnitude star. Outburst observations from Harvard plates in 1948 August established its precise position. The finding chart in Duerbeck (1987) shows a very crowded, somewhat ambiguous field. The WIYN *B*-band image of Figure 2 resolves this into a cluster of nine stars, revealing V465 Cyg at a *B* magnitude of 20.3, assuming it is the bluest star of the group. This star has coordinates that match the Duerbeck (1987) coordinates, so it is likely to be the nova. Spectroscopic confirmation is needed. Though apparently not the nova, the brightest star of this group ($19^h52^m38\overset{s}{.}17$, $+36°33'50\overset{''}{.}25$) has $B = 17.5$ and $V = 16.6$. Photometric observations with lower resolution or poorer seeing are very likely contaminated with light contributions from these other stars, which would reduce any photometric variations (see comments for UW Per).

TABLE 1

WIYN OLD NOVAE ASTROMETRY

| Nova | Nova Outburst | α (2000.0) | δ (2000.0) |
|---|---|---|---|
| SV Ari ........... | 1905 | 03 25 03.34 ± 0.01 | +19 49 52.94 ± 0.05 |
| V465 Cyg ....... | 1948 | 19 52 37.75 ± 0.01 | +36 33 53.03 ± 0.11 |
| SS LMi .......... | 1980 | 10 34 05.41 ± 0.02 | +31 08 08.38 ± 0.27 |
| V2104 Oph ...... | 1976 | 18 03 25.02 ± 0.01 | +11 47 57.10 ± 0.15 |
| GR Ori .......... | 1916 | 05 21 35.32 ± 0.01 | +01 10 12.19 ± 0.17 |
| V529 Ori ........ | 1678 | 05 58 20.17 ± 0.01 | +20 15 45.00 ± 0.15 |
| UW Per ......... | 1912 | 02 12 29.54 ± 0.01 | +57 05 18.46 ± 0.20 |
| UW Tri .......... | 1983 | 02 45 17.29 ± 0.02 | +33 31 26.31 ± 0.17 |

NOTE.—Units of right ascension are hours, minutes, and seconds, and units of declination are degrees, arcminutes, and arcseconds.

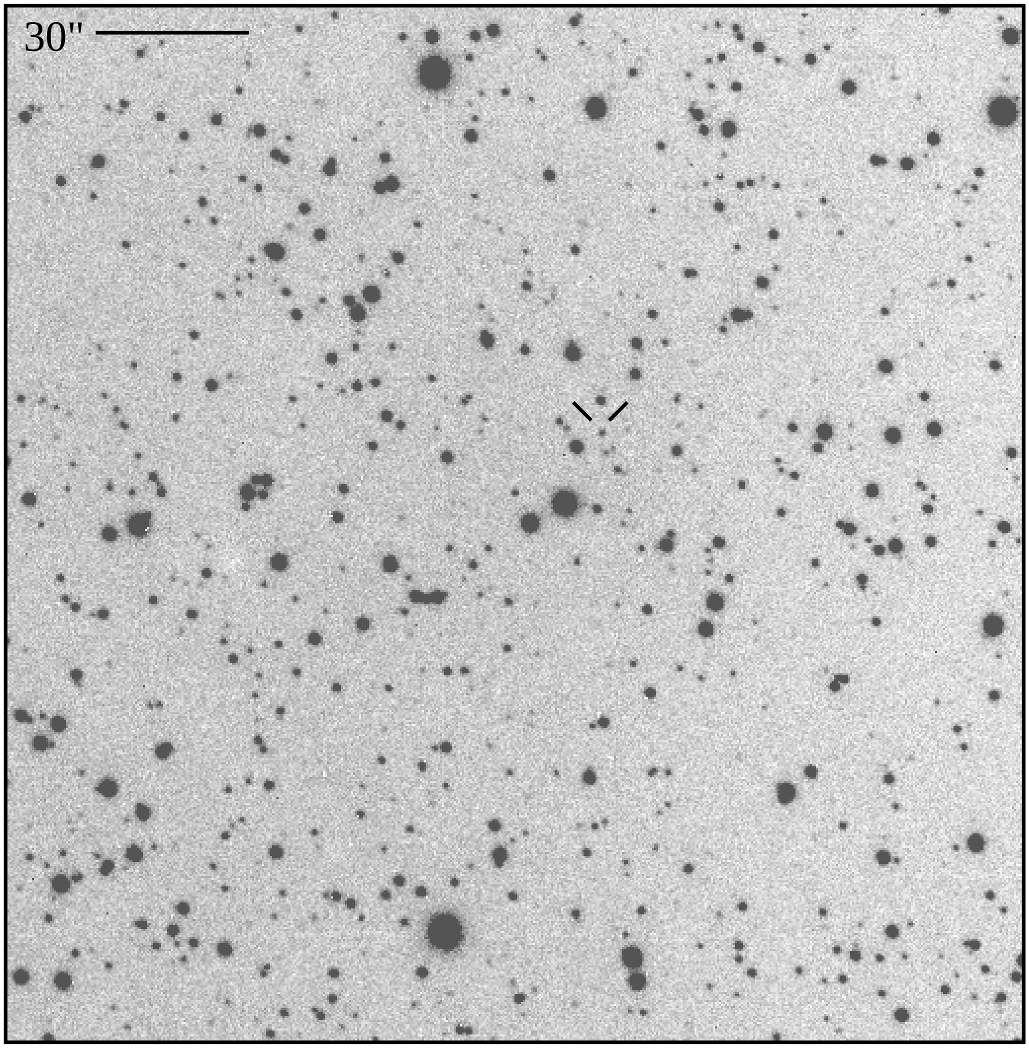


FIG. 2.—Same as Fig. 1, but for V465 Cyg. The star at the precise match to the coordinates in Duerbeck (1987) is also marked.

### 2.3. *SS LMi* (*Nova LMi 1980*)

According to Duerbeck (1987), it is not certain whether SS LMi is an extragalactic nova or an unusually large amplitude dwarf nova, partly because there was no POSS counterpart. Its discovery by A. Alksnis and L. Začs in 1980 April was reported in 1981 in IBVS 1972. Its finding chart is the *R*-band image in Figure 3. Its positional coincidence with Duerbeck (1987) is exact.

TABLE 2

WIYN OLD NOVAE PHOTOMETRY

| Nova | Julian Date | Filter | Magnitude | $\sigma_{mag}$ | Criteria |
|---|---|---|---|---|---|
| SV Ari (1905) | 2,449,631.85631 | *B* | 22.1 | 0.1 | 1 |
| V465 Cyg (1948) | 2,450,053.56650 | *R* | 20.1 | 0.1 | 1, 3 |
| | 2,450,053.57080 | *V* | 20.2 | 0.1 | |
| | 2,450,053.57340 | *B* | 20.3 | 0.1 | |
| SS LMi (1980) | 2,449,829.69085 | *B* | 21.6 | 0.1 | 1 |
| V2104 Oph (1976) | 2,449,829.93774 | *B* | 21.0 | 0.1 | 1 |
| GR Ori (1916) | 2,449,632.94194 | *V* | 22.8 | 0.1 | 1, 2, 3 |
| | 2,449,632.94761 | *B* | 22.7 | 0.1 | |
| | 2,450,053.86964 | *R* | 21.6 | 0.1 | |
| | 2,450,053.87394 | *V* | 21.5 | 0.1 | |
| V529 Ori (1667) | 2,450,053.90553 | *V* | 19.6 | 0.1 | 1, 2, 3, 4 |
| UW Per[a] | 2,450,481.64545 | *V* | 18.9 | 0.1 | 1, 3 |
| UW Tri (1983) | 2,449,631.80154 | *B* | 22.6 | 0.1 | 1, 2 |
| | 2,449,632.95477 | *B* | 22.9 | 0.1 | |

NOTES.— (1) Astrometry coincidence; (2) photometric variability; (3) $B-V$ color; (4) emission-line spectrum.

[a] See Table 4; photometry from the US Naval Observatory Flagstaff Station.

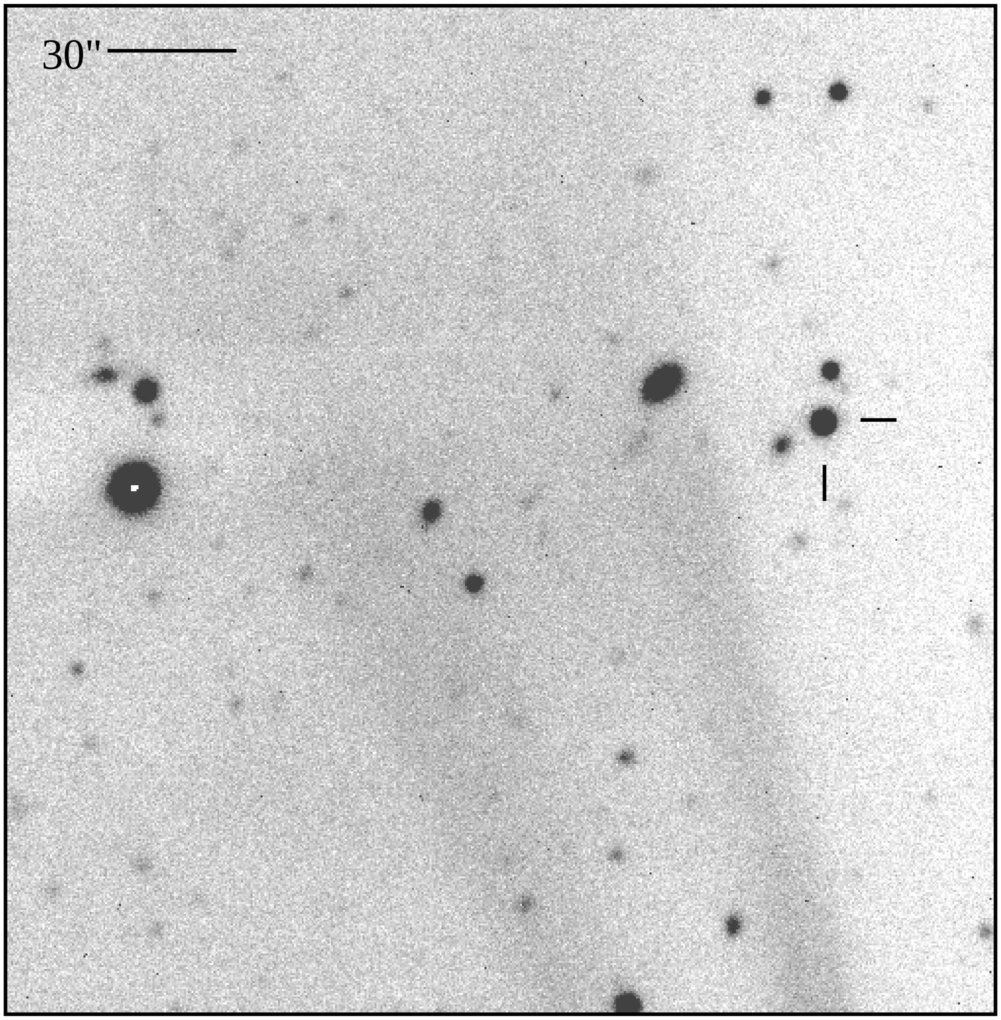


FIG. 3.—Similar to Fig. 1, but an $R$-band exposure, for SS LMi

TABLE 3

WIYN OLD NOVAE NONDETECTIONS

| Old Nova | Imaging Filter | Magnitude Limit | Spectral Fibers Assigned within 20′ |
|---|---|---|---|
| AS Psc ............ | *B*, *V* | 21, 22 | 12 |
| SY Gem........... | *B*, *V* | 21, 22 | 10 |
| VZ Gem .......... | *B*, *V* | 21, 22 | 20 |
| N Gem 1892...... | *B*, *V*, *R* | 21, 22, 23 | 5 |
| N Leo 1612....... | *B*, *V*, *R* | 22, 23, 23 | 20 |
| N Tri 1953........ | *B*, *V*, *R* | 22, 22, 23 | 13 |

TABLE 4

UW PER ASTROMETRY[a] AND PHOTOMETRY[b]

| Star | $\alpha$ (2000.0) | $\delta$ (2000.0) | $V$ (mag) | $B-V$ (mag) |
|---|---|---|---|---|
| UW Per.......... | 02 12 29.54 | +57 05 18.46 | 19.860 | 0.514 |
| Field star A...... | 02 12 29.74 | +57 05 19.43 | 17.701 | 1.142 |
| Field star B...... | 02 12 29.27 | +57 05 20.29 | 18.815 | 1.060 |
| Field star C...... | 02 12 28.61 | +57 05 17.88 | 18.866 | 1.616 |

[a] Errors are $\pm 0\farcs2$.
[b] Errors are $\pm 0.02$ mag.

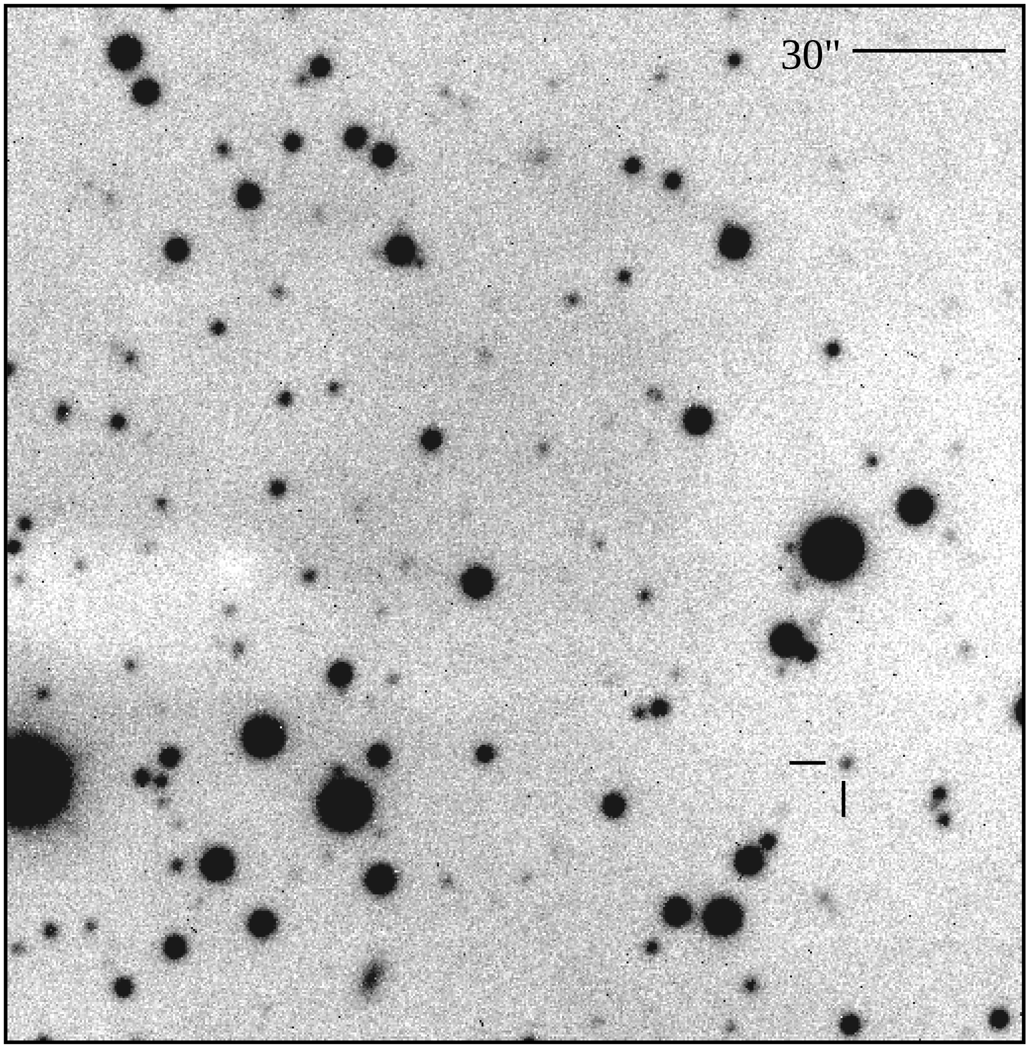


FIG. 4.—Similar to Fig. 1, but an $R$-band exposure, for V2104 Oph

### 2.4. *V2104 Oph* (*Nova Oph 1976*)

Listed as a poorly known nova by Duerbeck (1987), the light curve and spectra of V2104 Oph (Huth 1976; Pesch et al. 1976) were obtained near maximum light, and it was noted that there was no POSS counterpart on the red plate. It has remained unstudied since the time of its outburst. Its finding chart is the $B$-band image in Figure 4. This object is confirmed as being H$\alpha$ bright (R. Downes 1999, private communication).

### 2.5. *GR Ori* (*Nova Ori 1916*)

GR Ori is described by Duerbeck (1987) as a poorly known object at best. Figure 5 is the finding chart based on an $R$-band image of the GR Ori field. Its photometric variability is established in a series of $B$-band exposures represented by the differential light curve in Figure 6.

### 2.6. *V529 Ori* (*Nova Ori 1678*)

Duerbeck (1987) suggests that the position of V529 Ori is quite uncertain and that its existence is not firmly established. The V529 Ori field demonstrates the real power of this method of reconnaissance. Its finding chart is the $V$-band image in Figure 7. The star's photometric variability is established in the series of $B$-band exposures represented by the differential light curve in Figure 8. Figure 9 is a spectrum of the nova candidate lurking in the field showing strong H$\alpha$ emission. Follow-up observations are encouraged to determine if this is indeed the cataclysmic variable or some other object capable of H$\alpha$ emission (e.g., T Tauri or RS CVn star). These two most obvious alternatives, however, have their problems. T Tauri stars in the Orion star-forming regions have apparent magnitudes in the range $m_v = 11$–$13$ (Sterzik et al. 1995), while V529 Ori appears near 19th magnitude. Also, an RS CVn type star would usually show a much richer spectrum than that of Figure 9 if it did indeed contain an active late-type star. If our candidate is indeed the nova, it would be the oldest ever recovered.

### 2.7. *UW Per* (*N Per 1912*)

According to Duerbeck (1987), this old nova is thought to be a dwarf nova because of its low amplitude, rapid decline from maximum, and additional brightenings observed in 1915 and 1922. The finding chart in Duerbeck (1987) shows a suspicious single star. The WIYN $V$-band image in Figure 10 resolves this into a cluster of four stars. UW Per is being monitored by the Indiana RoboScope (Honeycutt et al. 1990; Honeycutt & Turner 1992), and its light curve has shown very little variability over the past 6 years, fluctuating in $V$ from 17.55 to 17.04 ($V_{\rm avg} = 17.26$, $\sigma_v = 0.08$).

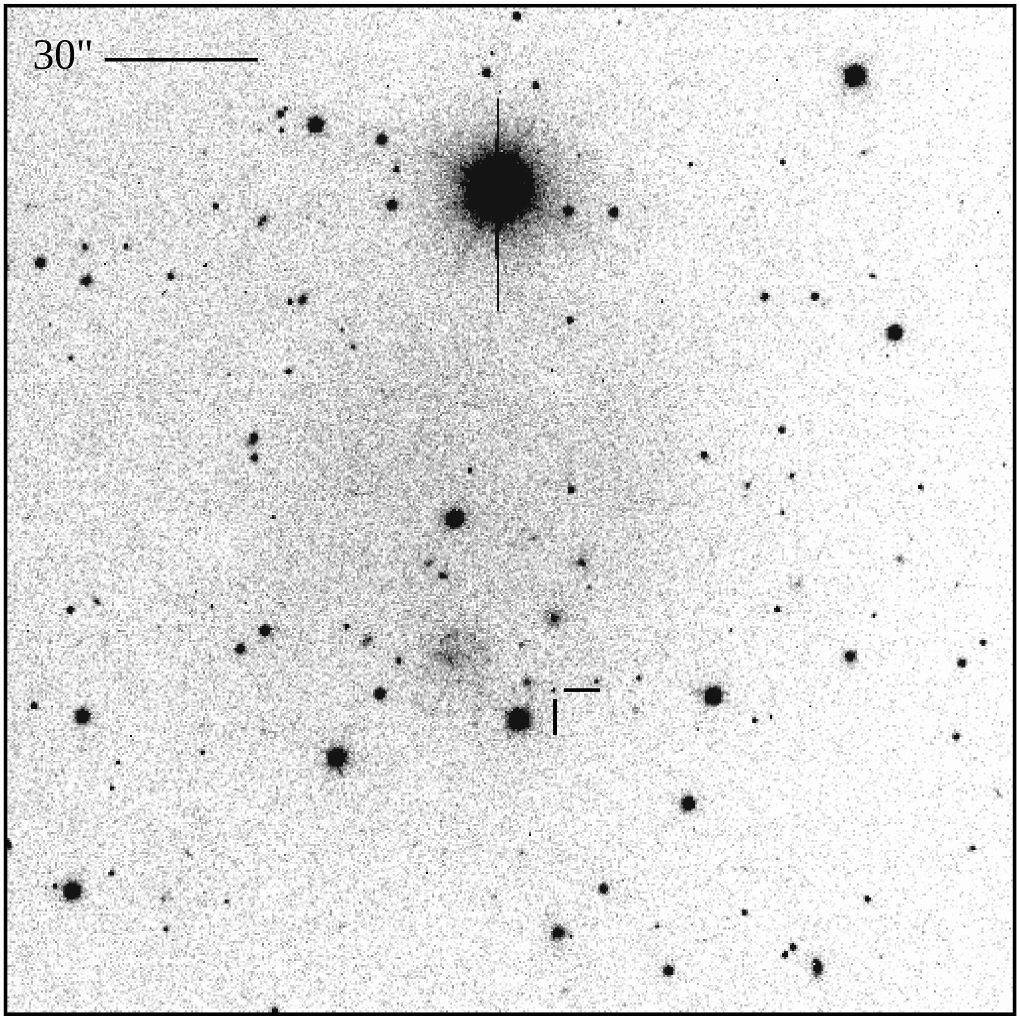


FIG. 5.—Similar to Fig. 1, but a $V$-band exposure, for GR Ori. The faint nebulosity 15″ east-northeast of the variable is a spiral galaxy.

However, the four stars in Figure 10 are unresolved on RoboScope images, and therefore the contributions from the other three stars would diminish any variability, much as in the case of V446 Her (Honeycutt et al. 1997). Thus, the

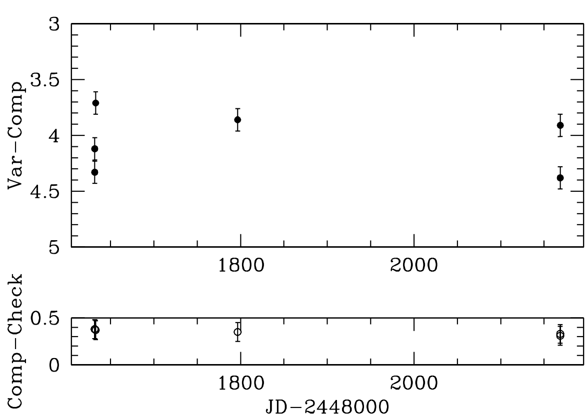


FIG. 6.—Differential $B$-band light curve of GR Ori showing its variability. *Top*, variable minus comparison star; *bottom*, comparison minus a check star. The comparison and check stars used were 20″ south-southeast and 30″ south of the variable, respectively.

$\pm 0.25$ mag variations recorded by RoboScope could be as much as 1.6 mag variations if the effects of the other three stars were removed. This could also help explain its apparent low-amplitude outbursts observed in 1915 and 1922. Color information for the four resolved stars obtained from the 1.0 m telescope of the US Naval Observatory in Flagstaff is given in Table 4. The bluest star, presumably the nova, is the faintest of the four and is closest to the brightest star in the group.

### 2.8. *UW Tri* (*N Tri 1983*)

Aside from its discovery and position (Aksenov 1976; Argyle 1976), nothing else was known about this poorly studied nova until the observation of a 14.7 mag outburst in 1995 (Vanmunster 1995). This makes it more likely to be something other than a classical nova. Its finding chart is the $B$-band image in Figure 11. Its photometric variability is established in the series of $B$-band exposures represented by the differential light curve in Figure 12.

## 3. CONCLUSION

As stated before, it is important to recover as many of the oldest novae as possible to compare observations with

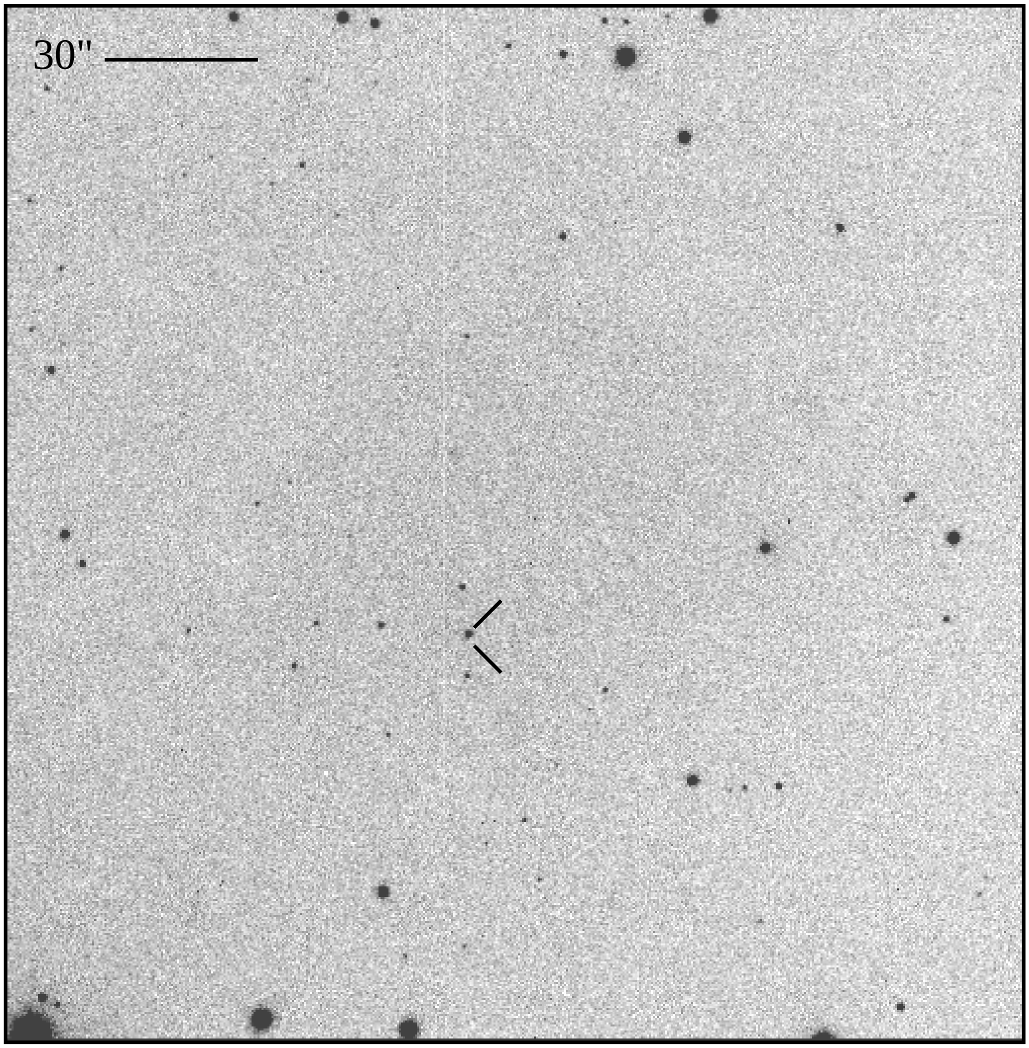


FIG. 7.—Same as Fig. 1, a *B*-band exposure, but for V529 Ori

theory. Exactly how the accretion rate varies during the interval between nova outbursts is still far from resolved. It is an interesting question because of the possibility that these systems become very faint as the accretion rate falls, which would imply that large numbers of uncataloged faint or detached cataclysmic variables may exist (Shara et al. 1986; Vogt 1990; Naylor et al. 1992; Duerbeck 1992). The present search was successful in recovering additional systems by probing to fainter levels than are generally available, suggesting that even deeper searches of old nova fields may eventually yield statistically meaningful samples to bear on this issue.

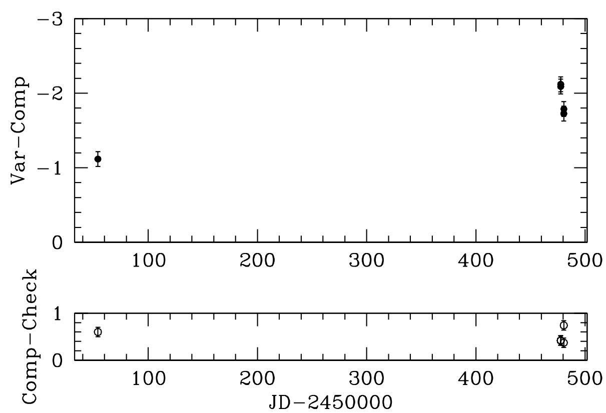


FIG. 8.—Similar to Fig. 6, but a differential *V*-band light curve, for V529 Ori. The comparison and check stars used were 5″ north and 5″ south of the variable, respectively.

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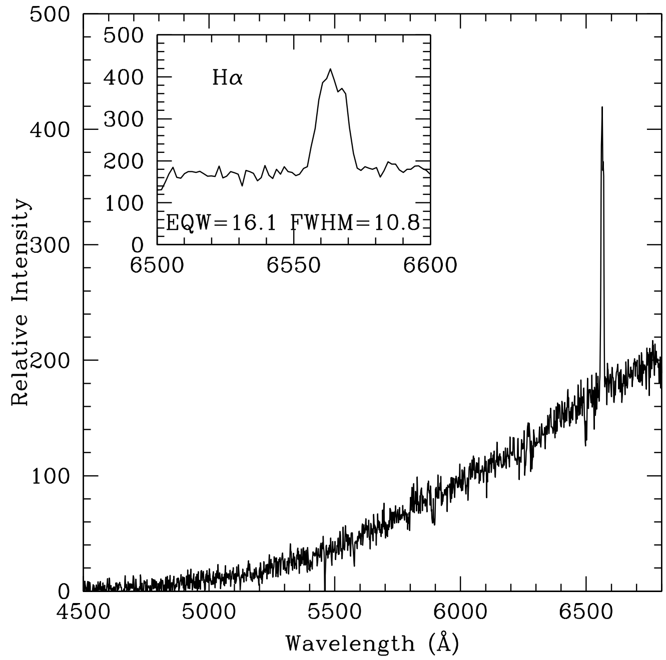


FIG. 9.—The emission-line object in the V529 Ori field showing strong Hα emission with an otherwise featureless spectrum

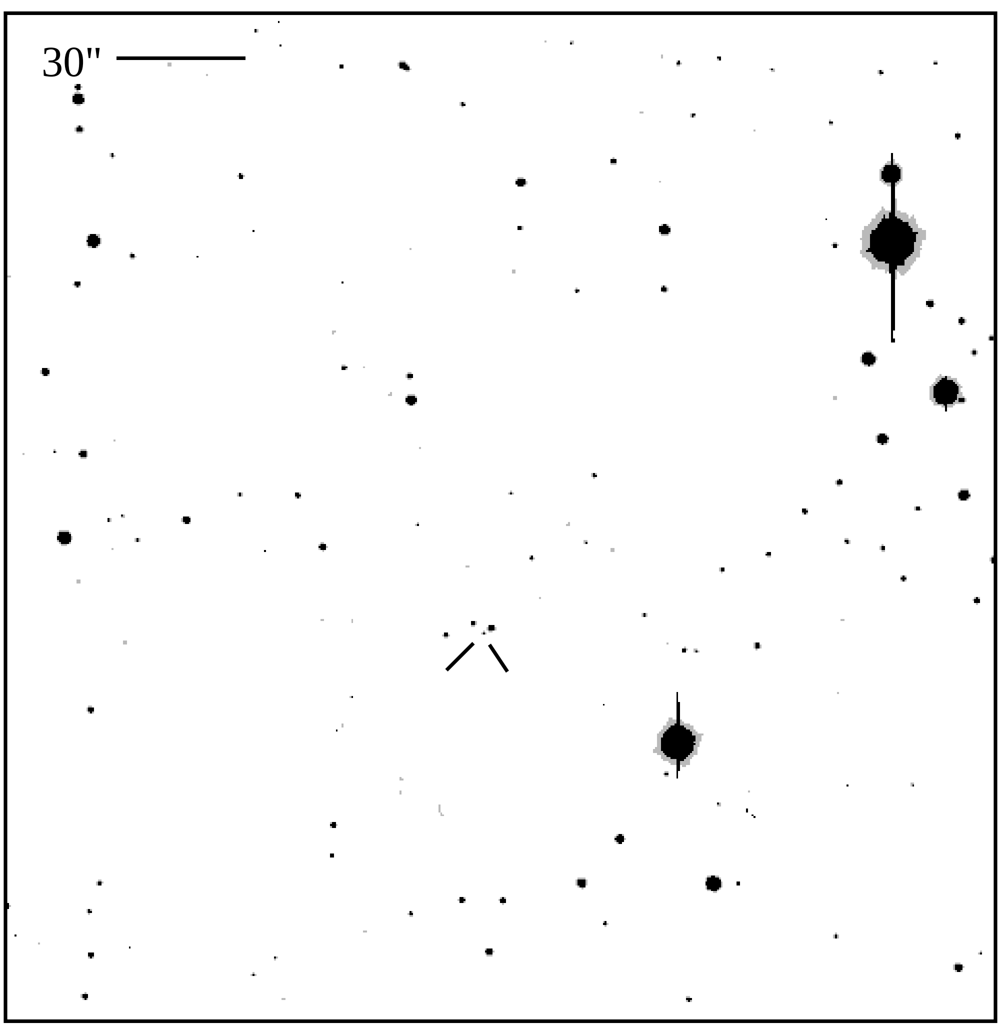


FIG. 10.—Similar to Fig. 1, but a *V*-band exposure, for UW Per

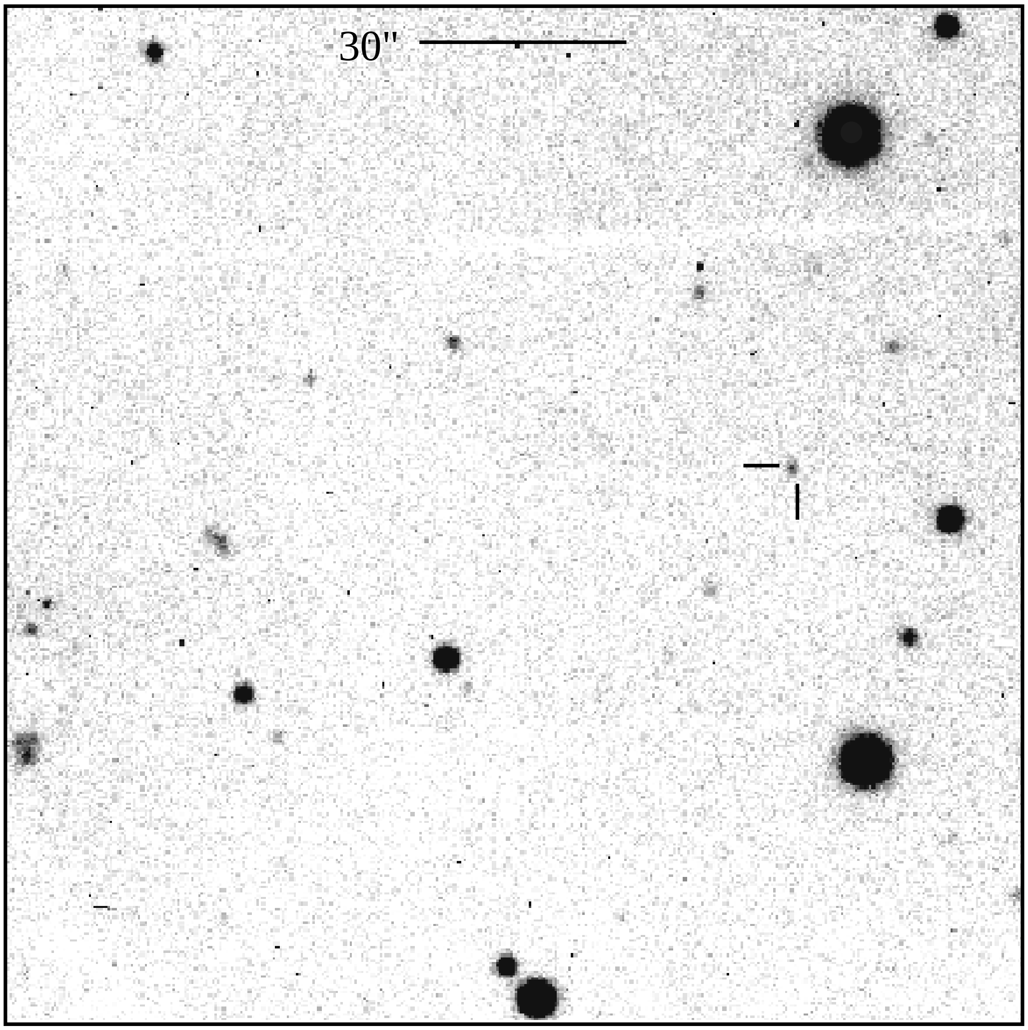


FIG. 11.—Same as Fig. 1, a *B*-band exposure, but for UW Tri

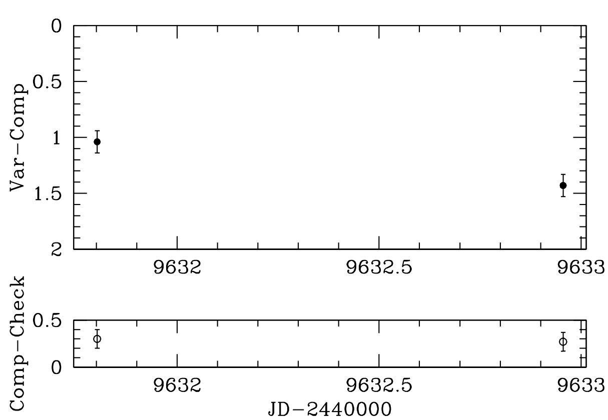


FIG. 12.—Same as Fig. 6, a differential *B*-band light curve, but for UW Tri. The comparison and check stars used were 20″ south and 40″ south of the variable, respectively.

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