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TEN NEW SEMI-REGULAR VARIABLES IN SAGITTARIUS

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We have conducted an extensive CCD monitoring program of the black hole binary (SAX J1819.3-2525 = V4641 Sgr) (Orosz et al. 2001). The goal of this study was to acquire accurate light curves in different bands to get better constraints on the physical parameters of the binary. The results will be presented elsewhere. As a byproduct of this campaign, we report here the discovery of ten new semi-regular variable stars in the field of V4641 Sgr.

Optical photometry was done with the YALO 1 m telescope at Cerro Tololo Interamerican Observatory (CTIO) (Bailyn et al. 1999), the CTIO 0.9 m telescope, the Dutch 0.9 m telescope at the European Southern Observatory (ESO), La Silla and the 1.0 m Jacobus Kapteyn Telescope (JKT) at La Palma (Table 1). The data were collected between July 2000 and October 2001. The IRAF data reduction package was used to apply the standard flat field and bias corrections to the images. For each telescope we made deep master images for each band by aligning the frames to common coordinate systems and coadding them. DAOPHOT (Stetson 1987, Stetson 1992) was used to do PSF fitting and to compute the instrumental magnitudes for each star. Stetson's program DAOMASTER was used to cross identify the stars in each data set and to construct time series photometry. Standard stars from the Landolt catalogue (Landolt 1992) observed with the JKT were used to place the magnitude scales on the standard system.

Table 1. Overview of the available datasets.

Observing run	Start date	End date	Frames	Filters	FOV
YALO	27-Mar-2001	15-Oct-2001	98	V and I	$10' \times 10'$
CTIO	21-Jul-2000	26-Jul-2000	255	U, B, V, R and I	$3\farcm3 \times 3\farcm3$
ESO	06-Jun-2001	28-Jun-2001	61	U, B, V, R and I	$3\farcm8 \times 3\farcm8$
La Palma	08-Sep-2000	14-Sep-2000	24	B, V, R and I	$8\farcm8' \times 2\farcm8$

Table 2. Photometric data.

Coordinates (J2000)	V [mag]	average $V-I$ [mag]	quasi period [days]	ID
18:19:16.8 −25:23:36.2	16.6 − 17.4	4.41	51	
18:19:22.0 −25:23:16.8	16.6 − 17.3	4.50	76	
18:19:10.6 −25:27:39.1	15.0 − 16.0	3.45	63	IRAS 18160-2529
18:19:02.5 −25:30:19.4	15.8 − 16.6	4.37	...	
18:19:03.0 −25:29:34.5	14.5 − 15.1	3.17	...	
18:19:03.7 −25:26:30.9	15.6 − 16.1	2.81	...	
18:19:06.5 −25:24:11.5	17.8 − 18.7	5.21	...	
18:19:28.0 −25:30:13.5	15.2 − 15.7	4.12	67	
18:19:02.2 −25:24:05.9	15.4 − 16.0	3.84	94	
18:19:40.8 −25:27:13.1	16.5 − 16.9	4.29	69	

We have light curves for about 15 000 stars, most of which appear only in the YALO images, since the YALO telescope has the largest field of view (2048×2048 pixels with a pixel size of $0\farcs3 \times 0\farcs3$, although the effective field of view of the aligned images was about $9' \times 9'$). We searched for variables using two simple techniques. First we computed the standard deviation σ of the light curves and made plots of σ vs. the mean magnitudes. Second, we computed Lomb-Scargle periodogram (Lomb 1976, Scargle 1982) for each star and sorted the stars according the highest L-S power. Once possible variables were flagged (either large σ or L-S power or both), the light curves were visually inspected and additional periodicity searches were done with the IRAF task 'pdm', an implementation of the phase dispersion technique of Stellingwerf (Stellingwerf 1978). Our sensitivity to large amplitude variables is high and we believe we have found $\gtrsim 95\%$ of the bright ($V \gtrsim 17^{\rm m}$) large amplitude ($\gtrsim 0.5$ mag) variables.

We found many variables. We report here a set of ten stars that seem to form a homogeneous group, see Figs. 1 and 2 for light curves and Figs. 3-12 for charts. Table 2 gives the positions, magnitude range and average $V-I$ colours of the ten stars. An astrometric solution for the YALO master image was found using stars from the USNOA2 catalogue and the estimated 1σ errors are $\lesssim 0\farcs5$ in each direction. The names of the stars are based on their coordinates in equinox 2000 and are given the prefix YALO. For example the first star in Table 2 at RA=18:19:16.8, DEC=−25:23:36.2 has the name YALO J181916.8-252336. Only one star has a plausible identification in SIMBAD: YALO J181910.6-252739 is probably IRAS 18160-2529.

One of the characteristics of all ten stars is that they are relatively red: average $V-I$ colours are between $2\fm8$ and $5\fm2$. The extinction in the direction of V4641 Sgr is relatively low ($E(B-V) = 0.25$, Orosz et al. 2001), so the red colours are not due to interstellar dust. The stars show slow and quasi-periodic variations with time scales between about 51 and 94 days and amplitudes in V of $\sim$1 magnitude. The red colours, the relatively large amplitude and the slow variability are characteristic of cool Asymptotic Giant Branch (AGB) stars (Sterken and Jaschek 1996, Kerschbaum et al. 2001).

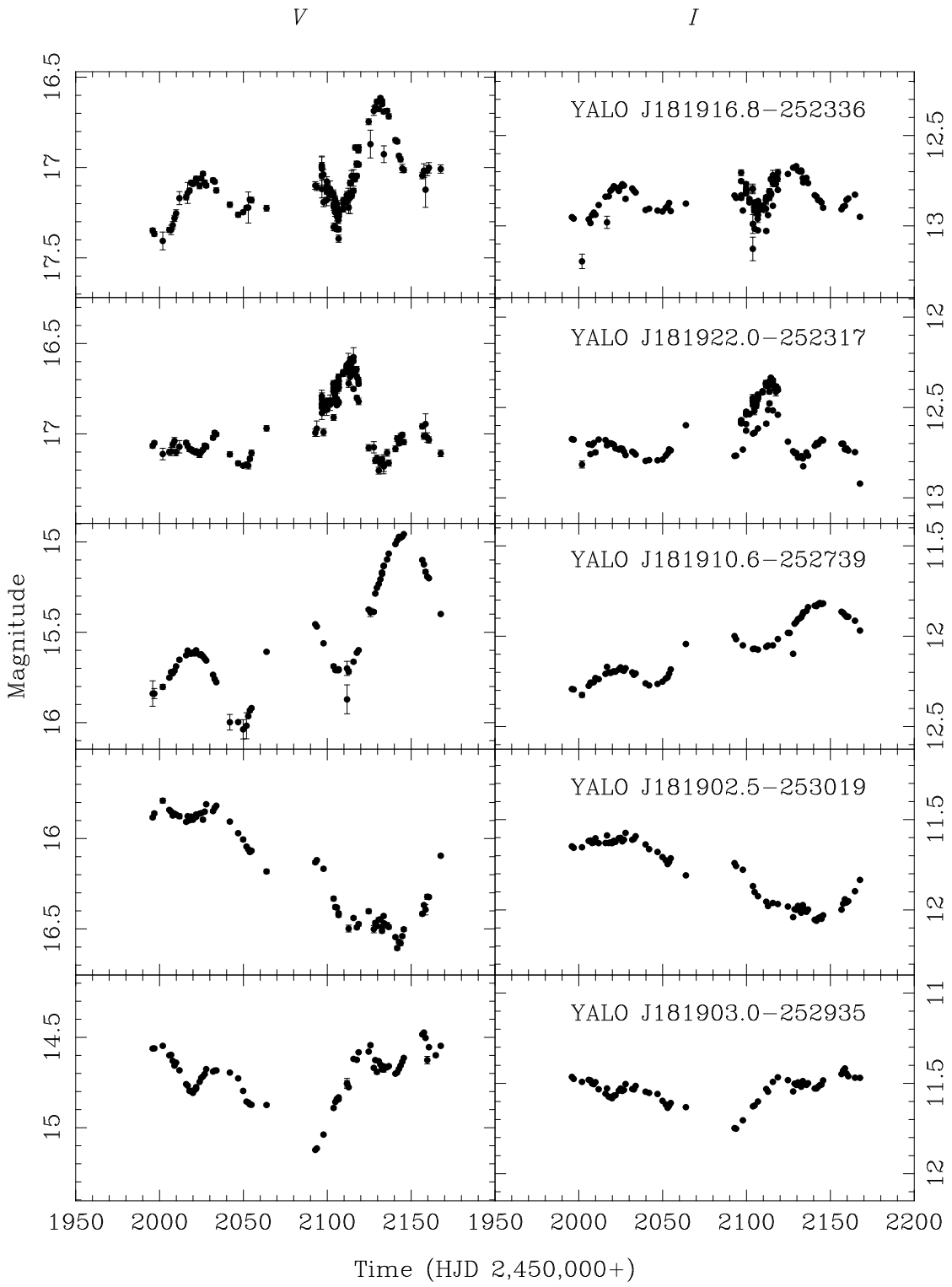

Figure 1. Light curves for five variables in V (left panel) and I (right panel).

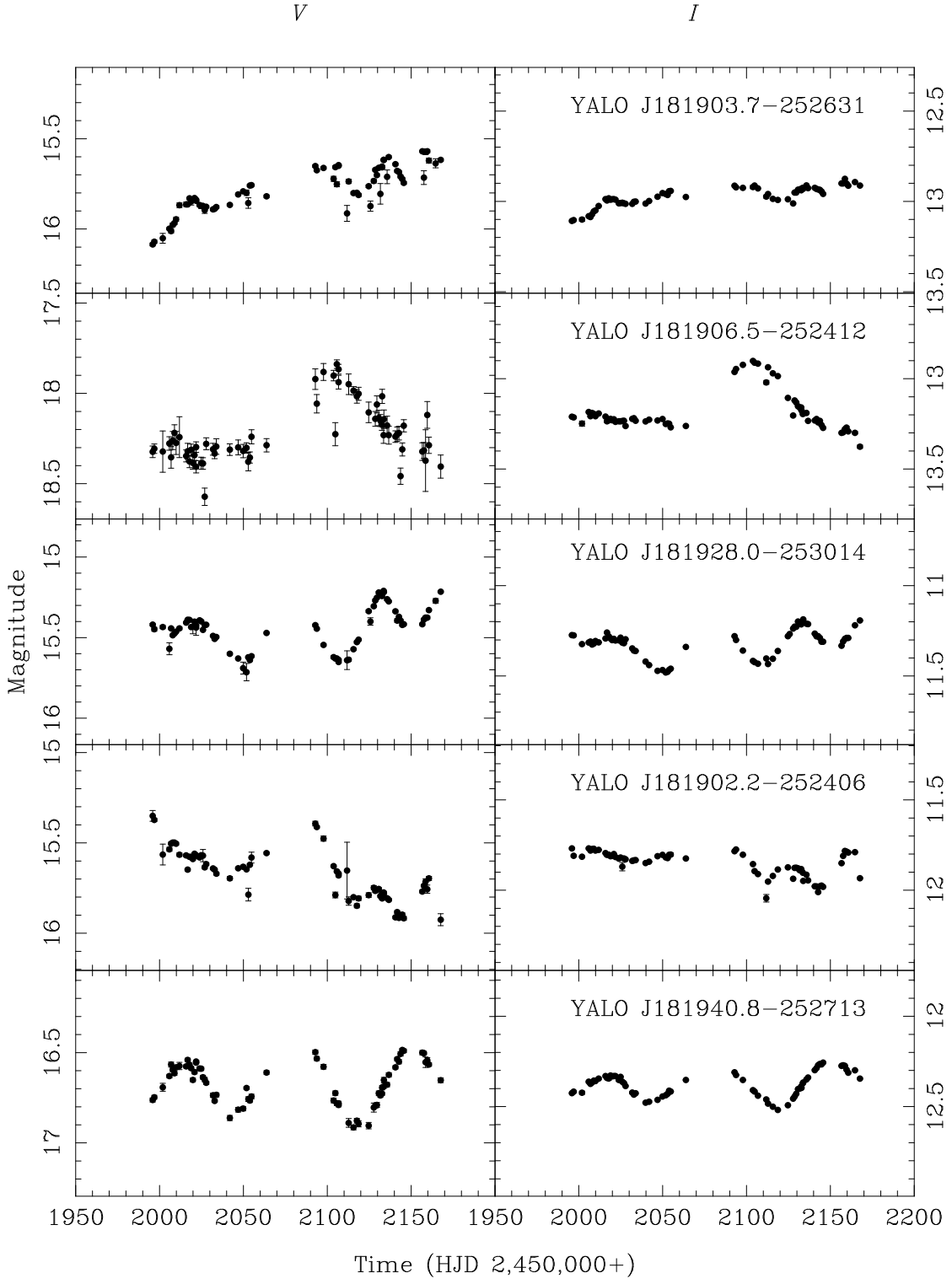

Figure 2. Light curves for five variables in V (left panel) and I (right panel).

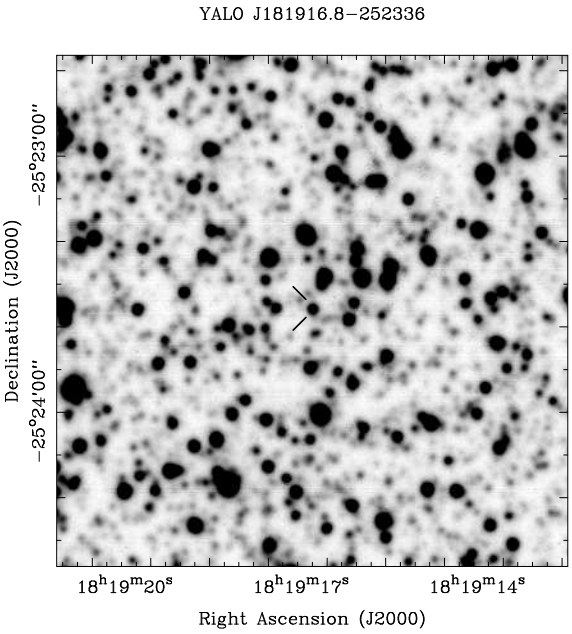

Figure 3. V-band finding chart of YALO J181916.8-252336. Source is in centre.

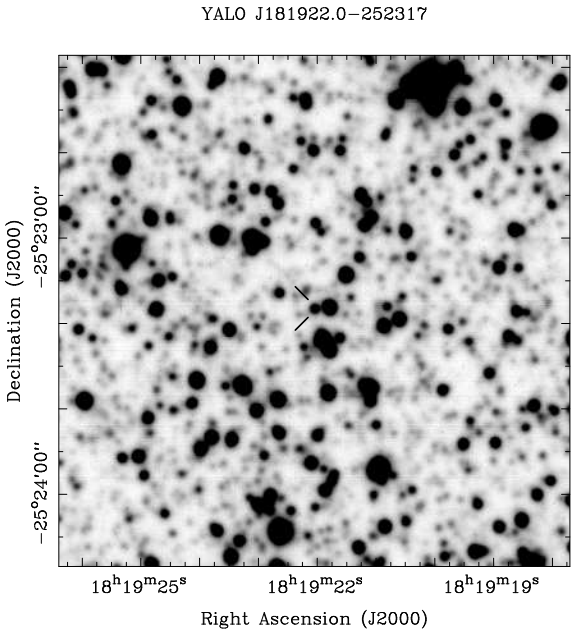

Figure 4. V-band finding chart of YALO J181922.0-252317. Source is in centre.

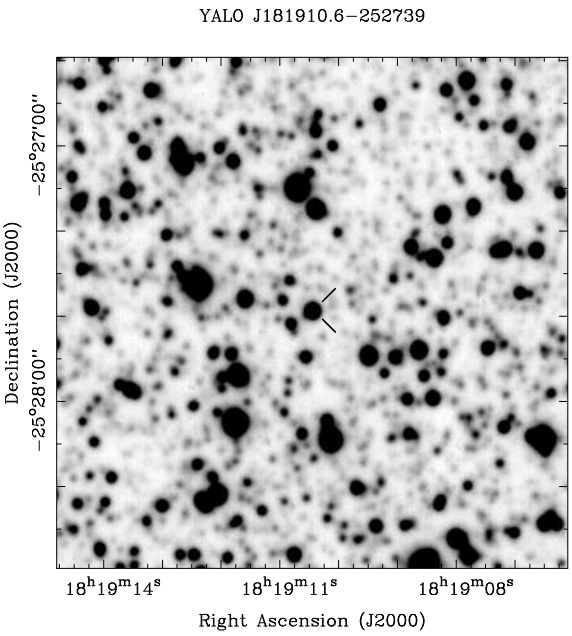

Figure 5. V-band finding chart of YALO J181910.6-252739. Source is in centre. Note: The first star to the south-east is a variable star.

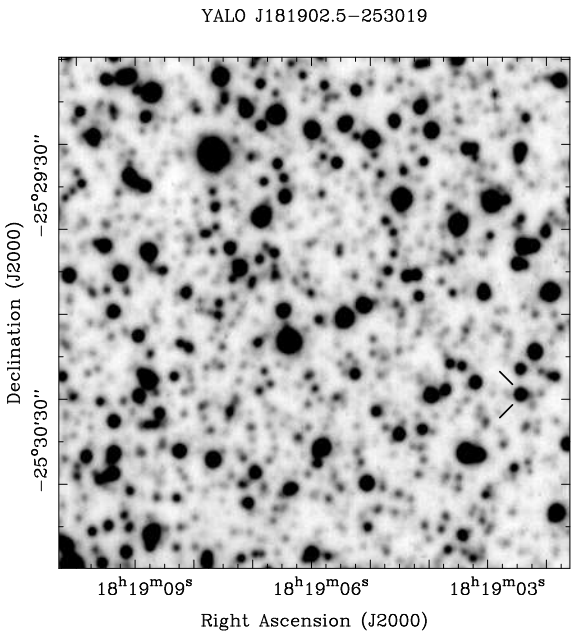

Figure 6. V-band finding chart of YALO J181902.5-253019. Source is lower-right of centre.

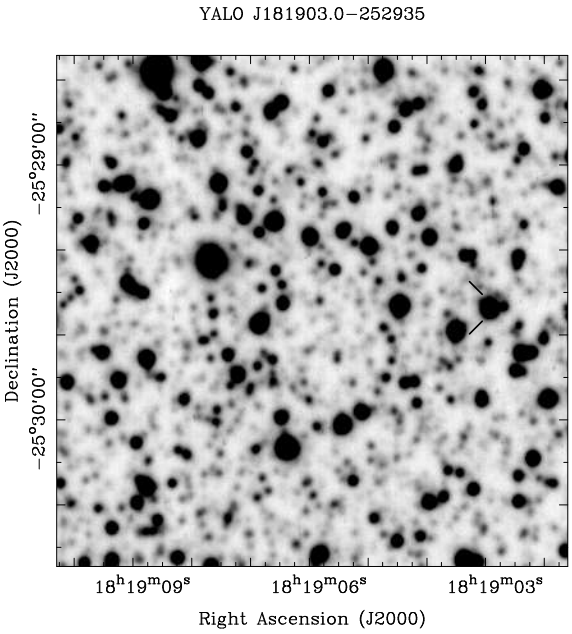

Figure 7. V-band finding chart of YALO J181903.0-252935. Source is right of centre.

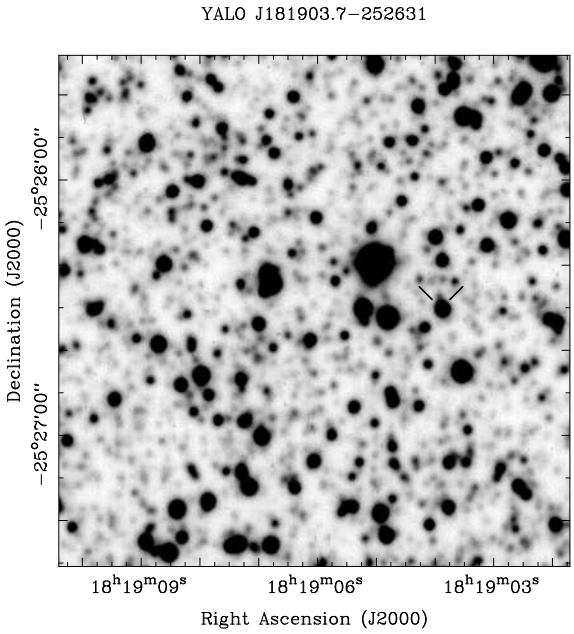

Figure 8. V-band finding chart of YALO J181903.7-252631. Source is right of centre.

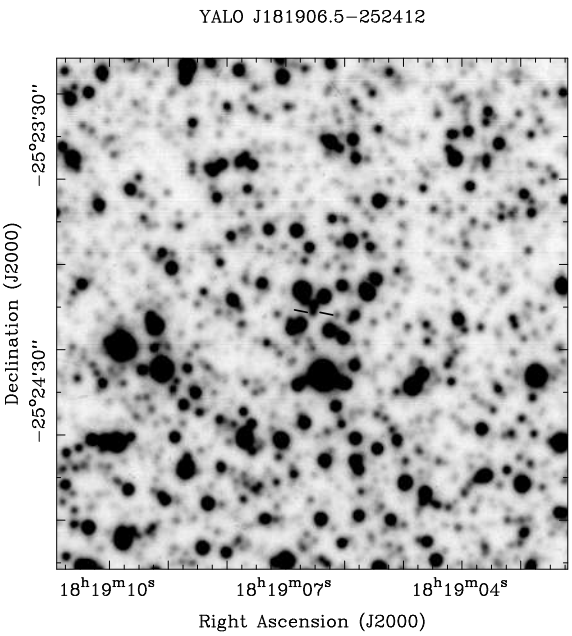

Figure 9. V-band finding chart of YALO J181906.5-252412. Source is in centre.

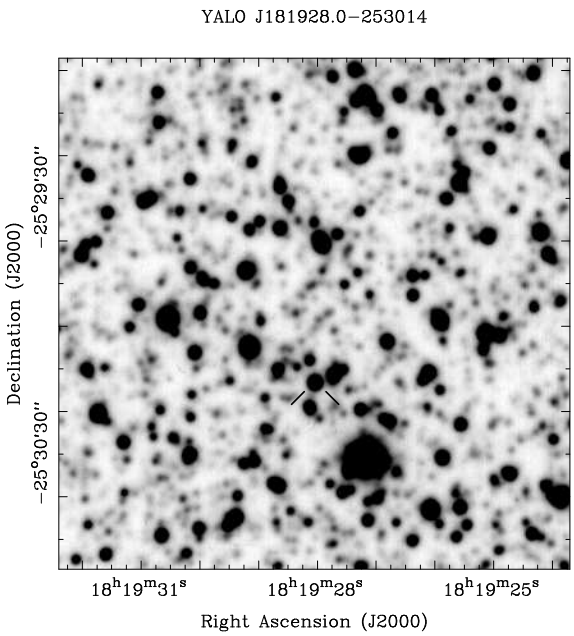

Figure 10. V-band finding chart of YALO J181928.0-253014. Source is below centre.

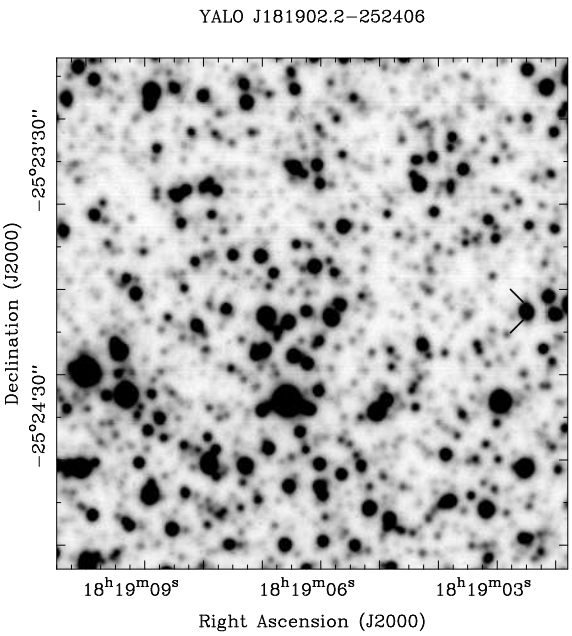

Figure 11. *V*-band finding chart of YALO J181902.2-252406. Source is right of centre.

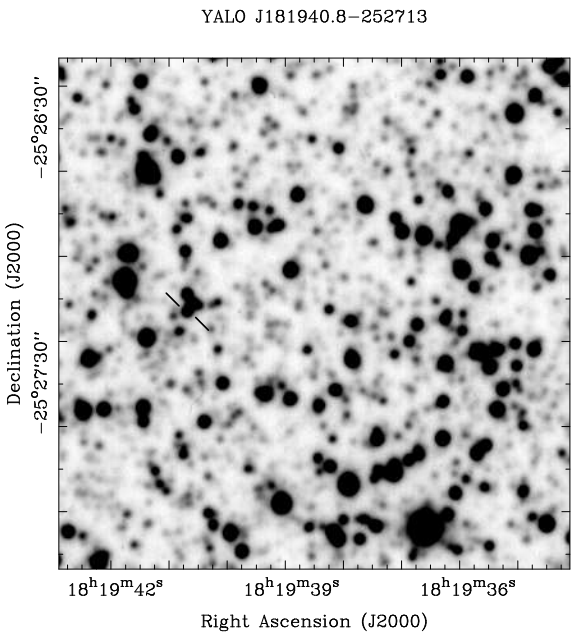

Figure 12. *V*-band finding chart of YALO J181940.8-252713. Source is left of centre.

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