Quasi-Speckle Imaging of Sigma Ori: Searching for Low-Mass Cluster Members in the Inner 30” of the Cluster

William H. Sherry[1], Frederick M. Walter[2], Scott J. Wolk[3]

(1) National Solar Observatory & National Optical Astronomy Observatories

(2) SUNY Stony Brook

(3) CfA

The σ Ori Cluster

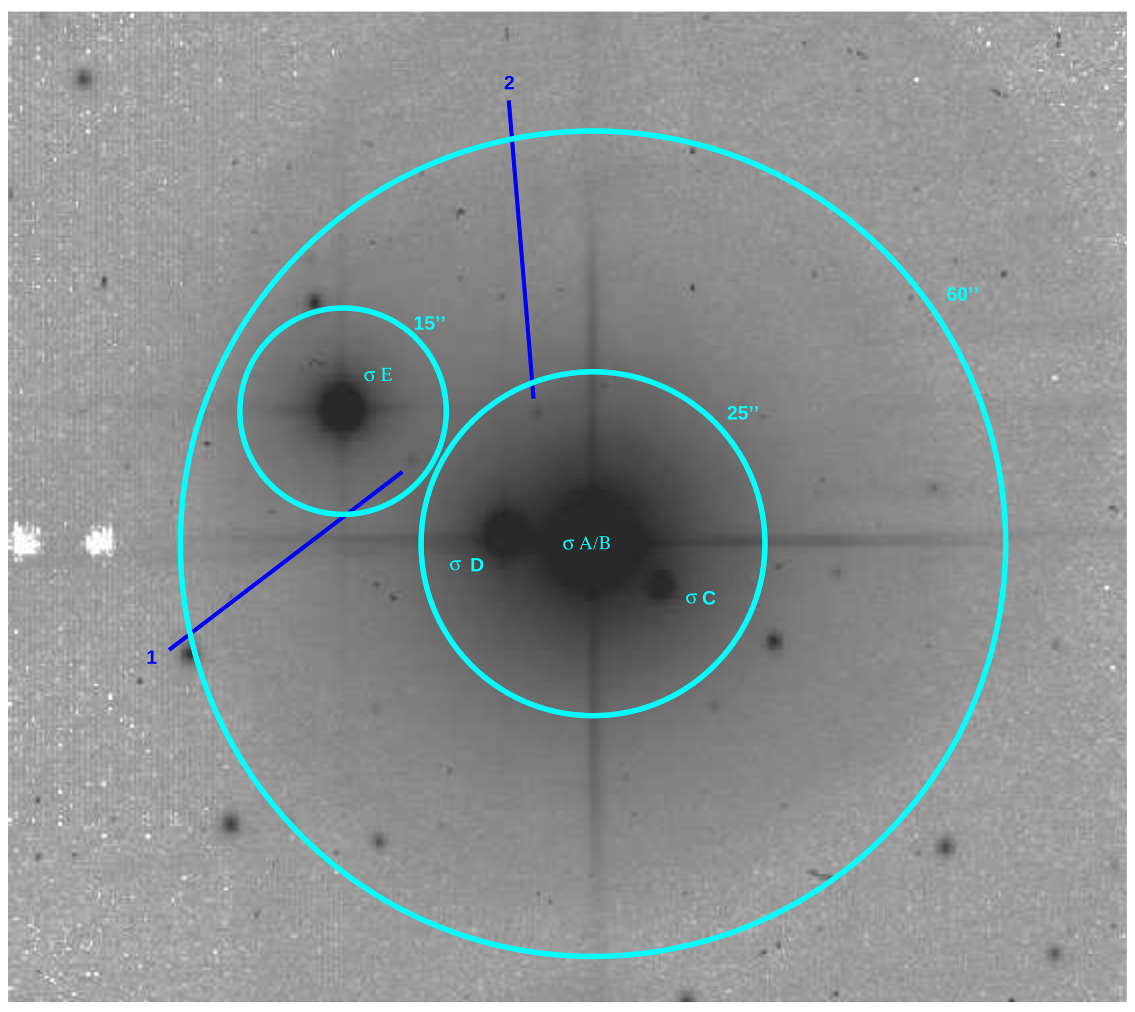
The σ Ori system is comprised of five stars. The primary, σ Ori A/B, is a 0.″2 binary with a combined V=3.8 mag. The A component is an O9V star and the B component is a B0.5V star. The faintest member of the quintet is σ Ori C, an A2V star with V~ 9. The D and E components are B stars with V$\sim$6.5 mag. The σ Ori system lies at the center of a cluster of low-mass PMS stars. The $\sim$3 Myr old σ Ori cluster contains $>$200 stars (3). The cluster has a radius of $\sim$0.5° (3). The spatial density of low-mass cluster members peaks at the the position of σ Ori A/B, even though the data are much less complete near σ Ori.

Why Use 100 Sub-Second Exposures to Search for Faint Stars?

Our previous photometric surveys for low-mass cluster members used exposure times of 300s per band to find V$\sim$20 cluster members. We always avoided the central 30″ of the cluster because the very bright members of the σ Ori system saturated many of the pixels in that region. The combination of bleeding from the bright stars and saturated diffraction spikes obscured a large fraction of the central region of the cluster.

We need greater dynamic range to detect faint stars amidsts the dazzling O and B members of the σ Ori multiple system.

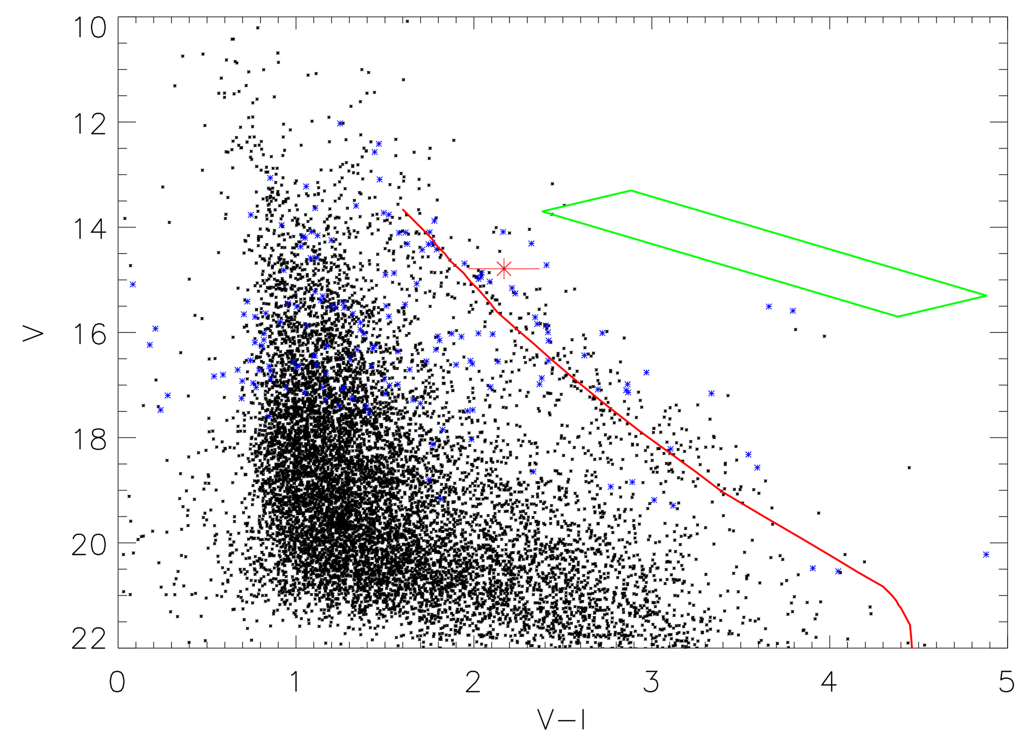
Photometry and Astrometry



These data were taken with the SMARTS 0.9m at CTIO on Nov. 25, 2003 under non-photometric conditions. All the images were processed by the IRAF QUADPROC routine to zero correct, overscan subtract, and flat field each image.

Photometry : Photometry was measured using a custom written IDL program which coadds the images for each filter, then runs the IDL port of DAOFIND to identify stars in each image, cleans the list of artifacts, then calculates aperture photometry for each star using an aperture with a radius between 2 and 17 pixels (0″.8 and 7″) radius. The program fits the aperture correction for each aperture as a function of position on the image. For each star it then selects the aperture with the best signal to noise. The astrometric solution for each image is determined by fitting the positions USNO-A2 stars to the measured positions of stars on the image using the *imwcs* program (2).

This program is supported in part by the NAI under Cooperative Agreement No. CAN-02-OSS-02 issued through the Office of Space Science. The NSO and the NOAO are operated by AURA for the National Science Foundation.



Figures

I Band Image :

- The image (left) was made by coadding 100 0.6s images.
- The circles mark the distance from σ Ori A/B in arcseconds.
- We found two unknown stars within 30″ of σ Ori A/B.
- Star 1 is marked as a red point on the CMD.
- Star 2 lies within the green lines on the CMD.

ID	V	I	V−I
star 1	14.8±0.2	12.6±0.1	2.17±0.2
star 2	-	10.86±0.07	>2.5

V vs. V−I CMD :

We have plotted star 1 in red on the CMD. Field stars and cluster members (3) that lie within 0.5° of σ Ori are plotted as black points. The red line is a 3 Myr isochrone (1) shifted to a distance of 440 pc. The blue points are the stars detected on both the coadded V and coadded I images. All of the blue points correspond to stars detected by our previous survey (3). Star 1 is located just above the cluster's isochrone. Based upon our fits to the field star distribution (3), the field star contamination is less than 10% at this position on the CMD. Star 1 is a probable member of the cluster with M$\sim$0.7 $M_\odot$.

We detected star 2 only on our I band image. At the position of star 2 on our V band image the sky is about 50% brighter than near star 1, but there is no trace of star 2. This suggests that star 2 is very red.

We used an upper limit of V=13.0 and a lower limit of V=16 to estimate the position of star 2 on the CMD. This gave us the region marked by the green lines. Star 2 is at least 2 magnitudes brighter than the cluster's isochrone. It is most likely a foreground M dwarf.

Results

We have identified two stars with V$>$14 in the inner 30″ of the σ Ori cluster. Star 1 lies on a region of the CMD where $>$80% of stars are cluster members. Based upon its V−I color, we expect it to have a mass of $\sim$0.7 $M_\odot$. Star 2 appears to be a foreground M dwarf.

References

[1] Baraffe, I. et al. 1998, A&A, 337, 403

[2] Mink, D. J., (1997) in Astronomical Data Analysis Software and Systems VI ASP Conf. 125, eds. G. Hunt & H. E. Payne, p. 249

[3] Sherry, W. H. Walter, F. M. & Wolk, S. J. 2004, AJ, 128, 2316