Finding Moving Stars in the Orion Nebula -

A Search for Stars in the M42 Region that have Moved in the Time between 1901 and 2008

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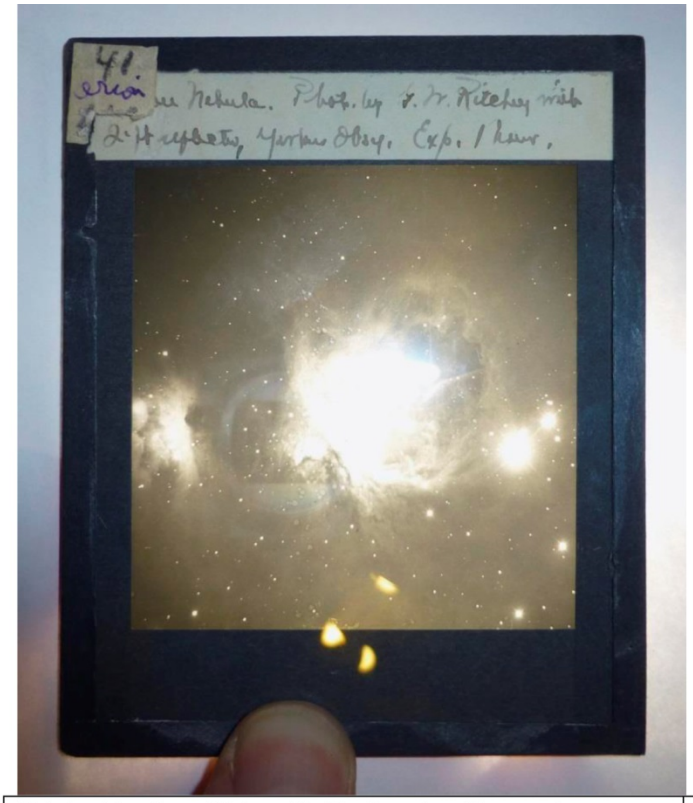
My wife and I were looking through an antique shop in Carlsbad California about ten years ago. I wasn't looking for anything specific, but there are always "targets of opportunity" that could turn up. I was looking at some watches in a glass case when I felt a tap on my shoulder. My wife said, "You really need to come and look at this." We went down an isle to a display cabinet upon which sat an old black box containing a number of glass lantern slides. I was stunned by what I saw in the box. It contained images of early 20th century telescopes along with images of images of large meteorites, photos of comets, photos of star fields, deep sky nebulae and many other things. It was obvious that she had found some sort of archive of old presentation slides about early astronomy in Southern California, made for some at present unidentified, organization. Many of the slides had hand written notes on them with names like G. W. Ritchey and E. E. Barnard. The antique shop was selling the slides individually, and some of them had already been sold. I wasn't sure what I would do with this collection of slides but I couldn't let it be sold off in pieces, so I bought the whole set of slides along with the black storage case.

There were 72 slides of size 4" X 3.24", which is a standard lantern slide configuration, with some of them apparently hand colored. I'm guessing that this presentation slide material was probably assembled beginning in approximately the 1930's through the early 1950's. The clue that some of slides were created in the early 1950's was the presence of some images of the mirror used in the Mount Palomar 200 inch telescope as well as astrophotographs taken through the 200 inch telescope. Judging from the image scale of some of the deep sky images I suspect that at least some of the slide transparencies are contact prints from the original glass plate negatives – what a treasure! I figured that I would at least scan them to make a digital slide set, but I was still working and I never found the time to start this project. They just sat in my home office for about a decade.

I retired the end of June of 2013 and decided that I would take advantage of the LAAS hosted public observing sessions on the Mount Wilson 60-inch telescope. As I reviewed the history of the 60-inch telescope on the Mt. Wilson web site I realized that G. W. Ritchey was the designer of the 60-inch and he actually did the final figuring on the 60-inch mirror. I signed up for a half-night session on the 60-inch. As I prepared for the observing session I searched through the old lantern slides to find the slides with G. W. Ritchey on the hand written notes. I found ten slides with his name included in the notes and they were mostly deep sky images and a few lunar images that he took around 1900 or 1901 on the Yerkes 24-inch (the prototype of the 60-inch) and images that he took through the 60-inch in 1909 to 1910, right after the 60-inch was put into service. One slide contained an image of M42 taken on the 24-inch at Yerkes Observatory. There was no date on this M42 slide image, but I'm assuming the date to be 1901 because historical records show G. W. Ritchey in residence at Yerkes Observatory for a number of years around 1901 as well as the fact that other slides have a 1901 date for images Ritchey had taken using the 24-inch. I scanned the M42 image slide and used Photoshop to restore the image to at least its former glory. The photographs in the figure below show the original lantern slide with the hand written note along with the restored M42 image. I started to think about what could be extracted from the somewhat faded transparency between the glass plates of the lantern slide.



Original Lantern Slide with the hand written note.	Scanned 1901 Lantern Slide – Black point and contrast adjusted.

I thought that having access to an M42 image that is about 112 years old afforded an opportunity to see if I could find any stars around the M42 image that have moved compared with recent M42 images. I did a search of Astronomy Picture of the Day archives and found an image of M42 (APOD dated 26 August 2009), covering roughly the same field of view as the G. W. Ritchey image. It was a superb color photograph by Kerry-Ann Lecky Hepburn taken on 2008-10-29, (http://www.weatherandsky.com/). Since this image was a full color image, I needed to convert it to black and white in Photoshop with the reds reduced and the blues enhanced to somewhat duplicate the early 20th century photographic plate spectral response. I then scaled and rotated the image in Photoshop to approximate the plate scale and orientation of the Ritchey image. Next, I opened the two images in "Images Plus" software to do a fine translate, rotate and scale aligning three star images in the Ritchey 1901 image with the same three stars in the 2008 image. These two aligned images were checked to be certain that the alignment reference stars were not among the stars that moved in the century time interval. I assumed that if the majority of the stars "moved" then one of the alignment stars was among the "moving stars", but there was no indication that I had chosen "moving star" as an alignment star. The next step was to "blink" the two images and look for moving stars.

Since the two images were taken with different telescopes and since the image in the lantern slide set was a transparency most likely made from a contact print of the original glass plate negative, I guessed that the image distortions caused by different telescopes and film distortion would lead to an imperfect alignment within Images Plus. Images Plus generated two new aligned M42 images that are of identical size and the aligned such that they can be blinked to search for translating objects. I was pleased to find that the alignment was actually fairly good when the images were viewed at full scale, but when I examined them with some magnification there were small misalignments among large numbers of stars. I used these two images to do additional image processing that was needed to correct for the local misalignments due to differential distortions caused by the completely different imaging technologies between 1901 and 2008.

I opened the aligned 2008 image and the aligned 1901 image in Photoshop to permit local alignment of the two images and to search for stars with significant proper motion over the interval of a century. I copied the 1901 image on top of the 2008 image on a separate layer. Opacity of the 1901 image was set to 50% permit alignment of stars within the two layers. The 1901 image size from the scanner is 265.18 mm by 224.87 mm (3132 pixels by 2656 pixels) with a plate scale of about 16 arc-sec/mm. I estimated plate scale using Software Bisque "The Sky X" with an extended stellar database to identify the stars and their angular separation, but there may be significant errors in this estimate because the star center point was visually determined.

I assumed that image distortion was small over a small portion of the image area, so I used the Navigation tool to magnify the images to 200% which results in a viewing frame that is about 1/5th of the whole image frame in both X and Y. I now have a search window field of view that was about 51.7 mm X 37.7 mm out of the 265.18 mm by 224.87 mm image size from the scanner. Stars within this field are aligned by unlocking Layer 2 (the 1901 Ritchey image) so this layer can be moved in X and Y relative to Layer 1 (the 2009 APOD image). After I aligned most of the stars within the search window field of view I blinked the 1901 image on and off to see if any of the stars within the field move relative to the majority of the other star images. I noted any moving stars and then moved on to the next field. The field of view frame is moved first in Y (overlapping the previous field of view by about 20%) and then repeated the above alignment and search process until the field of view reached the edge of the image in the Y direction. I then moved in X, overlapping the previous X field about 20% and then stepped in Y as above. My criterion for a "moving star" was if a star moves more than the presumed residual image distortion within the search window then it is considered to have actually moved in the roughly one century interval of time.

I was not surprised to find six stars with observable proper motion over the 107 year time interval were located in this search. The goal of this effort was not to get precise astrometric star positions but to use the extracted position information to permit star identification of the star that moved. It's very unlikely that any of moving stars that were found in this search would not have already been located and charted. The many recently completed stellar position surveys (Palomar, GSC, Hipparcos, etc.) should permit identification of the stars extracted from the 1901/2008 images and to confirm that they are stars with observable proper motion.

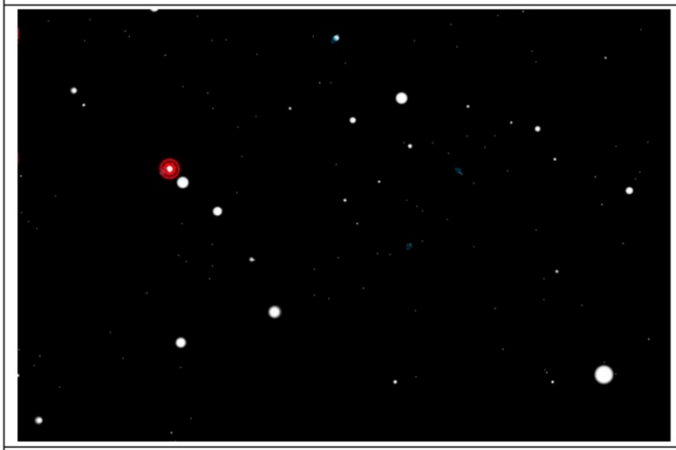
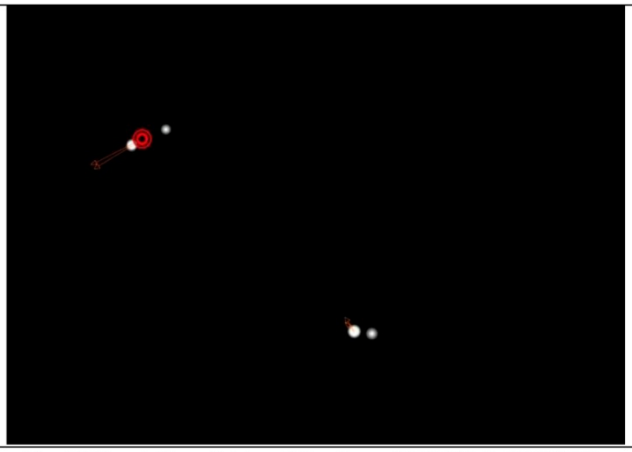
I identified the stars using Software Bisque "The Sky X" extended database, with the R.A. and Dec. given in current Topocentric coordinates. The distance from Earth to the identified proper motion stars is unknown, so it is technically not possible to know if these stars are in the M42 nebula, foreground or background. However, I'm fairly confident that the stars are foreground stars because M42 is estimated to be at a distance of 1344 (+/-20) light years and has a radius of about 12 light years, with an angular size of about 65 X 20 arc-minutes. At this distance, it is unlikely that my rather crude survey searching for moving stars would turn up anything at a distance of 1344 light years even over a time interval of a century.

I made image collages (See the illustrations below.) to show the aligned individual star fields containing a star that has moved in 107 year interval of time. Moving stars appear as "double stars" in the upper left hand image because the star fields of the 1901 image and the star fields of the 2008 image are superimposed with the 1901 image partially (50%) transparent so the 2008 star images show through. I added the thumbnail image in the upper right corner of the illustration to show the search field location relative to the entire image field of view. A red box in the thumbnail image gives the position of the search field within the entire image. I created star chart images from "The Sky X" with a field of view that approximately matches the same field of view in the photographic image in the upper left (presented in the lower left). I created another chart image (lower right) showing the identified star along with data from "The Sky X" about the star including its location, magnitude and proper motion information, when available, and a thin red arrow showing the direction of the proper motion. Proper motion information from "The Sky X" is expressed as an RA and DEC

vector giving the motion components that would occur over a 50-year time interval. In general, I found that the proper motion direction vector in the star database roughly matches the direction vector that I extracted from the two images. However, the magnitude of the proper motion vector in the star database may not match the magnitude extracted from the images. I'm not certain why some of the differences exist, but it may be a result from the fact that I visually extracted the information from images rather than using more exact software methods. One surprising outcome of this interesting project is that one star (Star-3) has a stated proper motion of zero from the databases that I used, but it obviously moved in the century time interval.

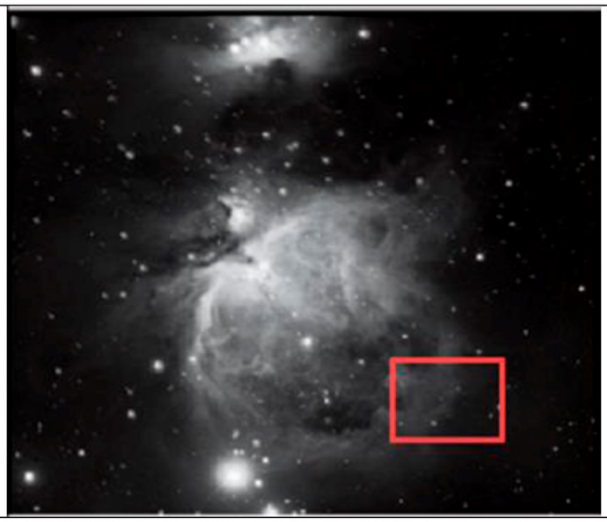
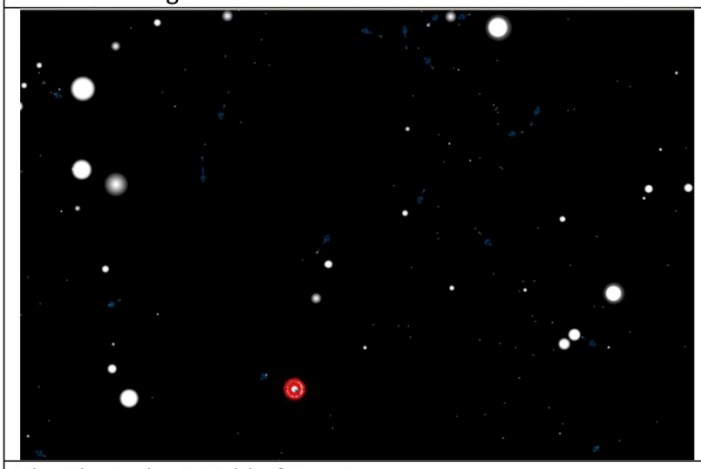
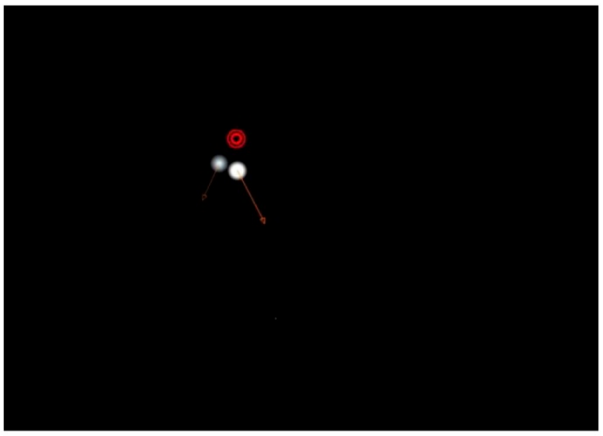
It was a fun project to see if an amateur astronomer could locate stars with proper motion by using early 20th century astrophotographs and comparing them with recent images of the same sky area. There are other early 20th century astrophotographs in my lantern slide set that can become a future project to search for stars with proper motion. For the near future, I will be scanning the lantern slide set in the next several months to make digital slide set available to others in the hope that someone may be able to provide clues to where these slides originated, when they were created, who created the slides and in what venue they were used as presentation visuals. My first guess is that the slides were used in a public astronomy related program connected with one of the Southern California observatories or at a planetarium or at a museum, but that doesn't narrow down things very much in Southern California.

Star-1

	
Star-1 Image Field: Proper Motion estimated 9.2 arc-sec; P.A. = 225 degrees	Star-1 Field Location Frame in the M42 Image
	
The Sky X Chart Field of Star-1	The Sky X Chart Star-1 Identification: **UCAC3 170:21943** RA (Topocentric): 05h 33m 28.87s Dec (Topocentric): -05° 19' 23.98" RA (2000.0): 05h 32m 45.68s Dec (2000.0): -05° 19' 49.08" Magnitude: 13.24 Catalog Identifier: UCAC3 170:21943 50-Year Proper Motion RA: 65.70 50-Year Proper Motion Dec: -33.20

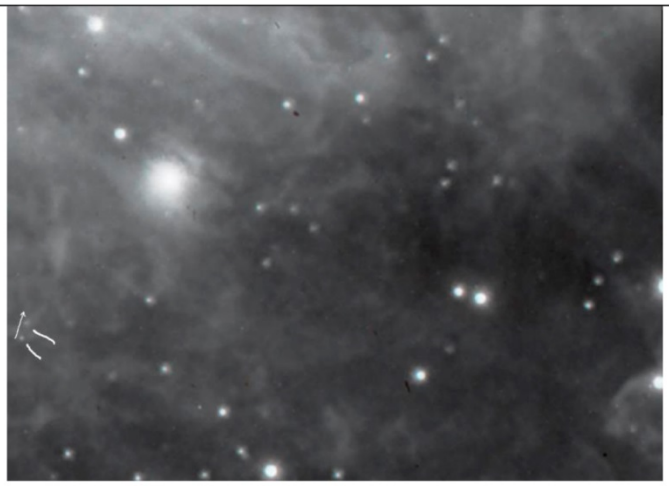
Star-1 Discussion: There is a significant difference between the database proper motion magnitude and the estimated magnitude from the M42 images. This difference is almost an order of magnitude, so it is not clear what the source of the error may be in the M42 image-based estimate. Estimated proper motion direction from the M42 images is within observational error compared with the database direction vector.

Star-2

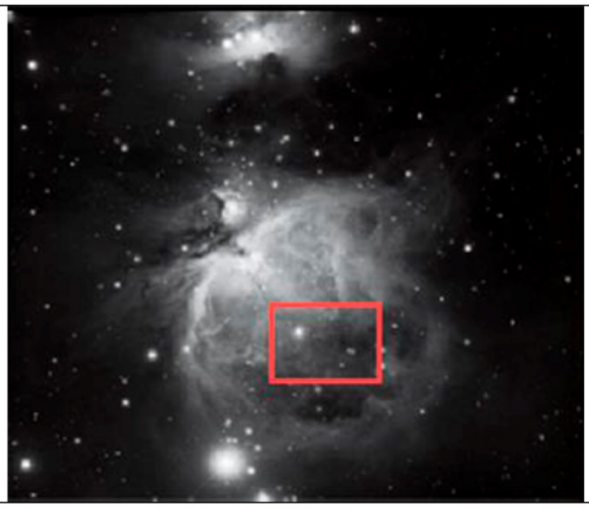
	
Star-2 Image Field: Proper Motion Estimated 44.3 arc-sec; P.A. = 143 degrees	Star-2 Field Location Frame in the M42 Image
	
The Sky X Chart Field of Star-2	The Sky X Chart Star-2 Identification: **GSC 4778:1355** Name 2: B-05 1290 RA (Topocentric): 05h 34m 12s Dec (Topocentric): -05° 45' 00" RA (2000.0): 05h 33m 29s Dec (2000.0): -05° 45' 24" Magnitude: 10.55

Star-2 Discussion: Even though the proper motion vector is shown in the star chart field detail of the identified star the magnitude data is missing from the information within the database included within "The Sky X". The direction of the proper motion vector approximately matches the direction vector extracted from the M42 images.

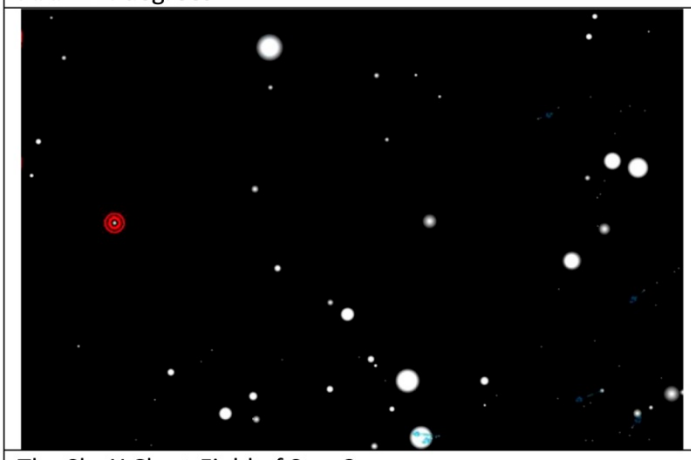
Star-3



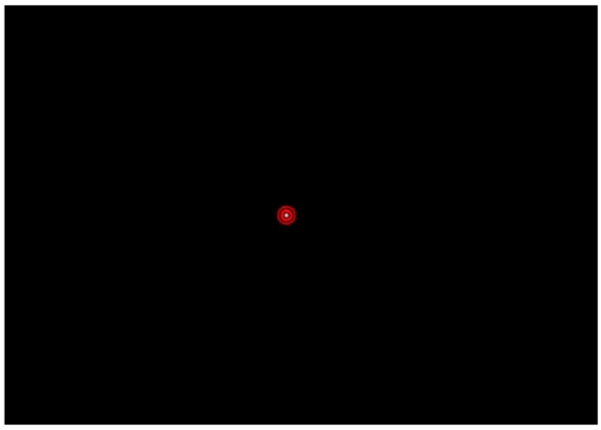
Star-3 Image Field: Proper Motion Estimated 20.2 arc-sec; P.A. = 14 degrees



Star-3 Field Location Frame in the M42 Image



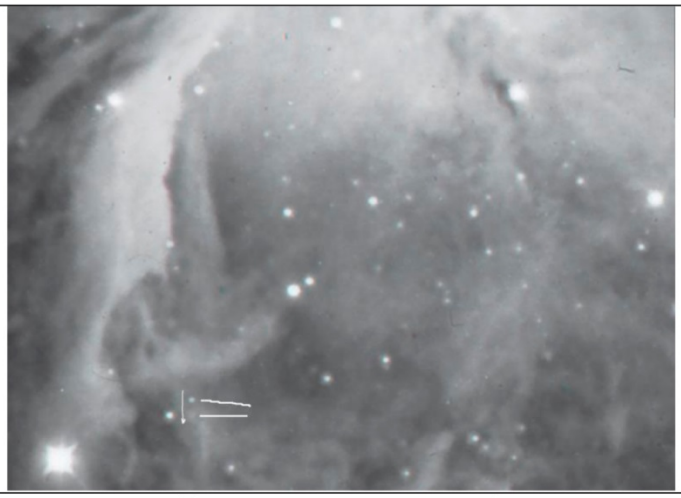
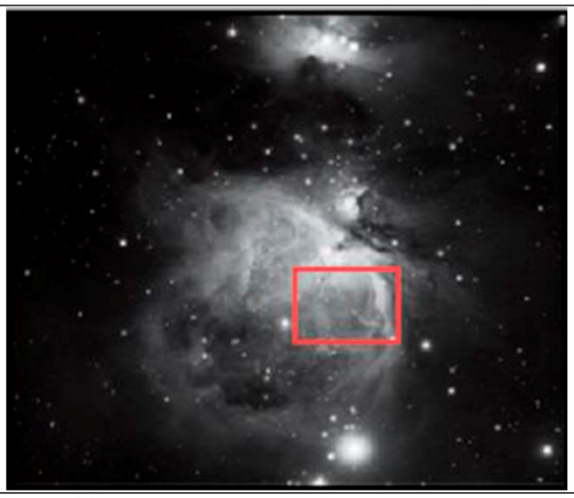
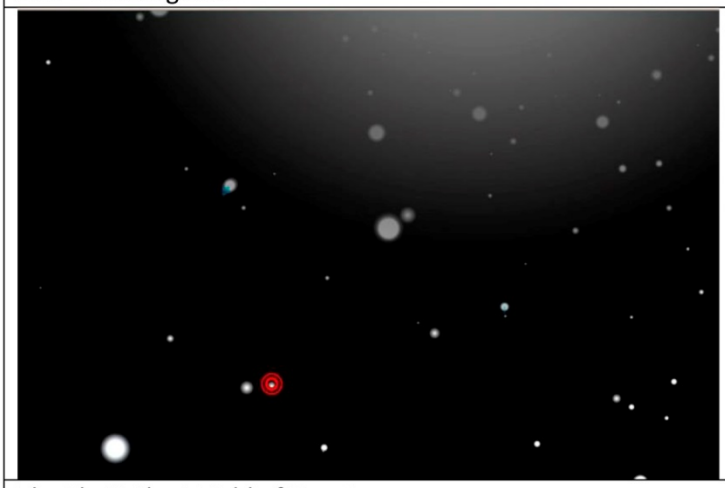
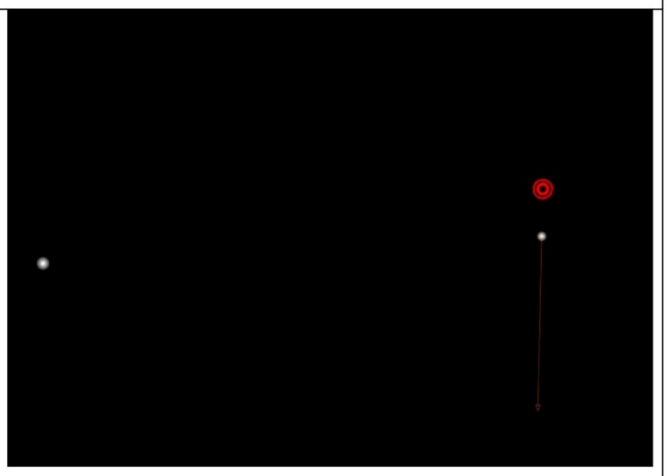
The Sky X Chart Field of Star-3



The Sky X Chart Star-3 Identification: **UCAC3 169:22519**
RA (Topocentric): 05h 35m 43.92s
Dec (Topocentric): -05° 37' 45.63"
RA (2000.0): 05h 35m 00.82s
Dec (2000.0): -05° 38' 07.96"
Magnitude: 15.36
Proper Motion RA: 0.00
Proper Motion Dec: 0.00

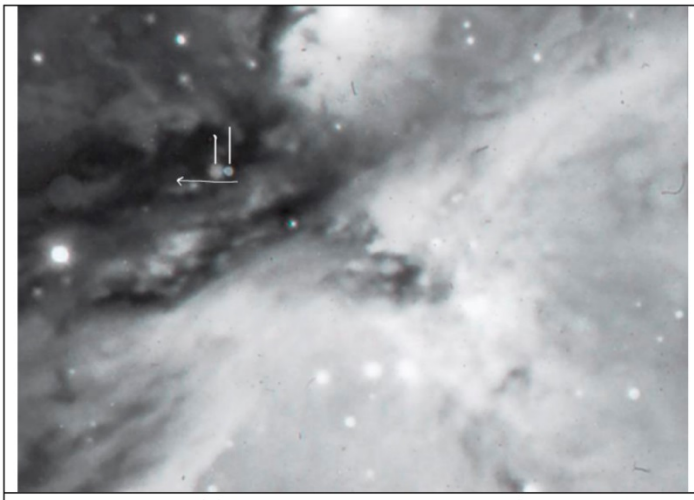
Star-3 Discussion: The database does not show proper motion information for Star-3 even though the M42 images clearly indicate proper motion. It is possible that another star catalog, that is not included in "The Sky X", may have proper motion information. It is odd that the UCAC3 database specifically indicates zero proper motion vector components. Perhaps, since this star is well within the M42 nebula, the proper motion information extracted from an automated stellar survey was confused by the presence of the nebula glow.

Star-4

	
Star-4 Image Field: Proper Motion Estimated 16.4 arc-sec; P.A. = 186 degrees	Star-4 Field Location Frame in the M42 Image
	
The Sky X Chart Field of Star-4	The Sky X Chart Star-4 Identification: **UCAC3 169:22648** RA (Topocentric): 05h 36m 24.16s Dec (Topocentric): -05° 36' 01.14" RA (2000.0): 05h 35m 41.06s Dec (2000.0): -05° 36' 22.65" Magnitude: 13.94 Proper Motion RA: 4.80 Proper Motion Dec: -209.20

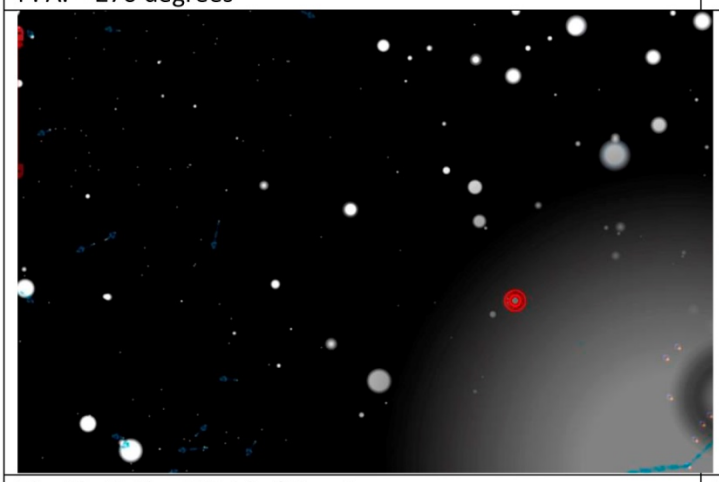
Star-4 Discussion: The proper motion vector extracted from the images approximately matches the database proper motion vector, but the magnitude is very different from the value extracted from the M42 images.

Star-5

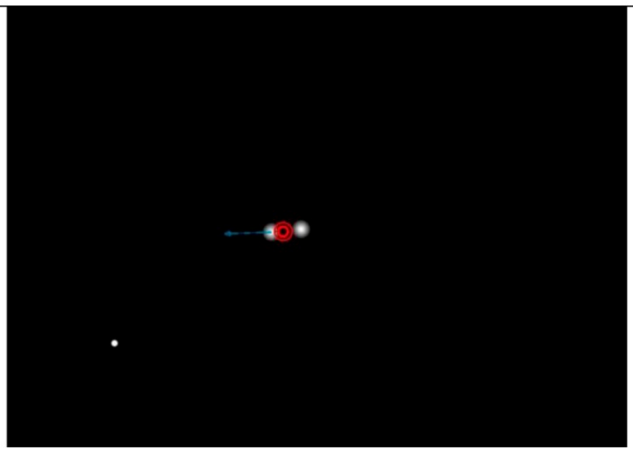


Star-5 Image Field: Proper Motion Estimated 14.6 arc-sec; P. A. = 270 degrees

Star-5 Field Location Frame in the M42 Image



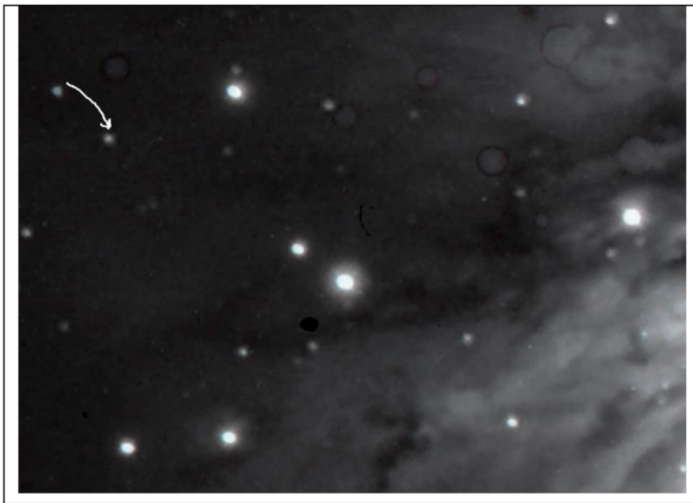
The Sky X Chart Field of Star-5



The Sky X Chart Star-5 Identification: **GSC 4774:863**
RA (Topocentric): 05h 36m 26s
Dec (Topocentric): -05° 19' 52"
RA (2000.0): 05h 35m 43s
Dec (2000.0): -05° 20' 13"
Magnitude: 11.00
Proper Motion RA: 173.80
Proper Motion Dec: -5.90

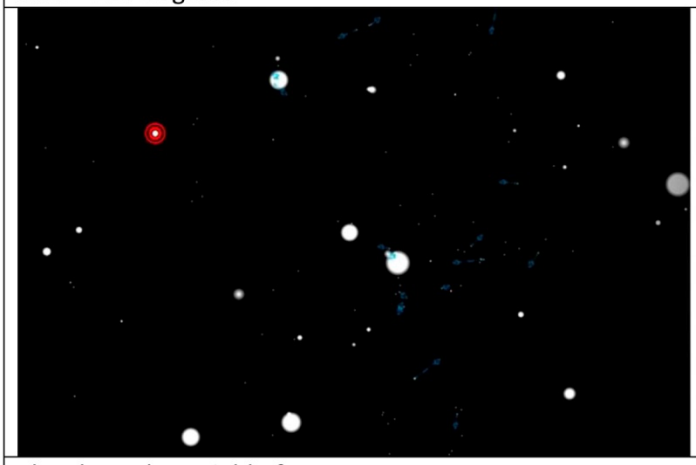
Star-5 Discussion: The proper motion vector extracted from the images approximately matches the database proper motion vector, but the magnitude is very different from the value extracted from the M42 images.

Star-6

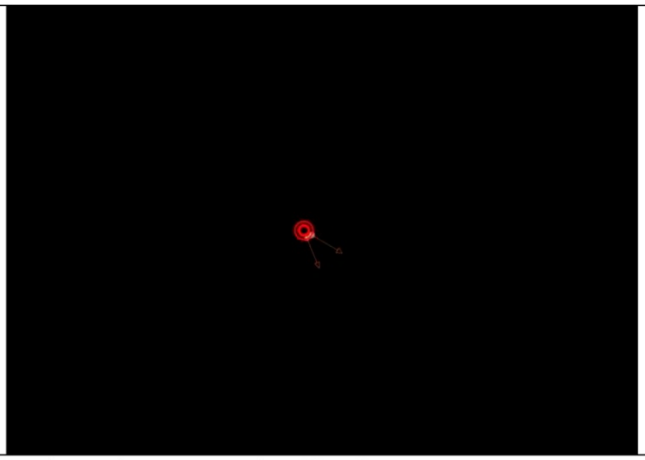


Star-6 Image Field: Proper Motion Estimated 86.6 arc-sec; P. A. = 137 degrees

Star-6 Field Location Frame in the M42 Image



The Sky X Chart Field of Star-6



The Sky X Chart Star-6 Identification: **UCAC3 170:22477**
RA (Topocentric): 05h 37m 35.18s
Dec (Topocentric): -05° 20' 53.54"
RA (2000.0): 05h 36m 51.99s
Dec (2000.0): -05° 21' 13.61"
Magnitude: 14.72
Proper Motion RA: -9.30
Proper Motion Dec: -22.50

Star-6 Discussion: The proper motion vector extracted from the images (137 degrees) is different from the database proper motion vector (157 degrees) and the magnitude is very different from the value extracted from the M42 images.