

High Proper Motion Stars

Objective: Obtain an image of a high proper motion star with a CCD and compare with an image at least 30 years old. Look for a detectable change of position and estimate the proper motion.

Background: To the naked eye, stars do not change their relative positions noticeably in a lifetime (100 years). But with a telescope, we can see some stars (especially the close, fast ones) move relative to others. A periodic component to the motion exists caused by the Earth's orbital motion around the Sun in a year. On top of this *parallax* is a more linear motion called *proper motion* (μ) caused by the relative motion of that star and our solar system. It can be divided into components parallel to RA (μ_{RA}) and Declination (μ_{DEC}).

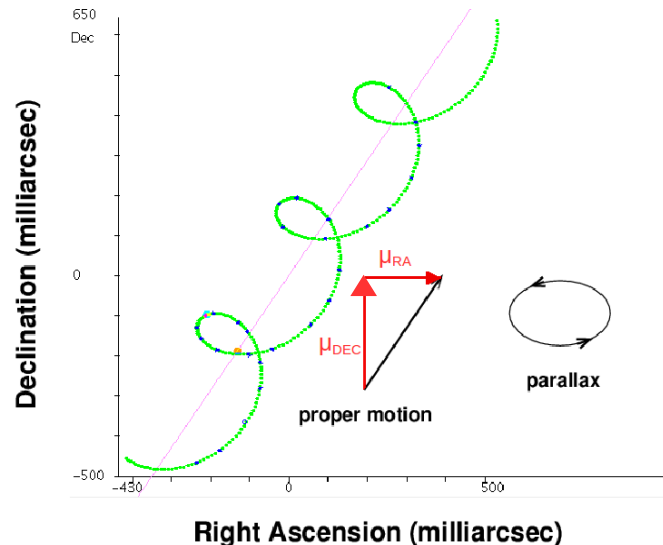


Figure 1: The star Vega's motion over about 3.5 years. It's μ_{DEC} is positive, but its μ_{RA} is negative.

A search for high proper motion stars visible from northern latitudes in February-March turns up two stars, both in Ursa Major. One is Groombridge 1830 (HD 103095), a 6th magnitude star with a proper motion of about 6"/yr. The other is Lalande 21185 (HD 95735), a 7.5 mag double star, type M2V (red), with a total proper motion of about 5"/yr. We will attempt to get an image of Lalande 21185.

Practice calculations prior to observing:

1. Using the following data for Lalande 21185, calculate the motion vector of this star from the year 1953.35 to 2019.2. Use $\mu_{\text{RA}} = -0.577$ "/year and $\mu_{\text{DEC}} = -4.7617$ "/year for Lalande. (RA increases East, so negative μ_{RA} points West, or right.)

How far East or West:

How far North or South:

Procedure:

1. Power up one of the telescopes with a CGE Pro equatorial mount. If it “wakes up” out of hibernation, it should already be aligned, otherwise it needs a 2-star alignment.
2. Slew to Dubhe in Ursa Major and do a “sync” on Dubhe once it is centered.
3. Start up Cartes du Ciel (Skychart) and connect to the CGE telescope by clicking on Telescope → connect Telescope. (There should be a Celestron telescope option.)
4. In Skychart, click on Setup → Chart, coordinates and then choose “Astrometric J2000” under “Type of coordinates”.
5. In Skychart, use the Search box to find HD 95735. Change the field of view to about 2 degrees. Center HD 95735 in the field of view. You should now see something like

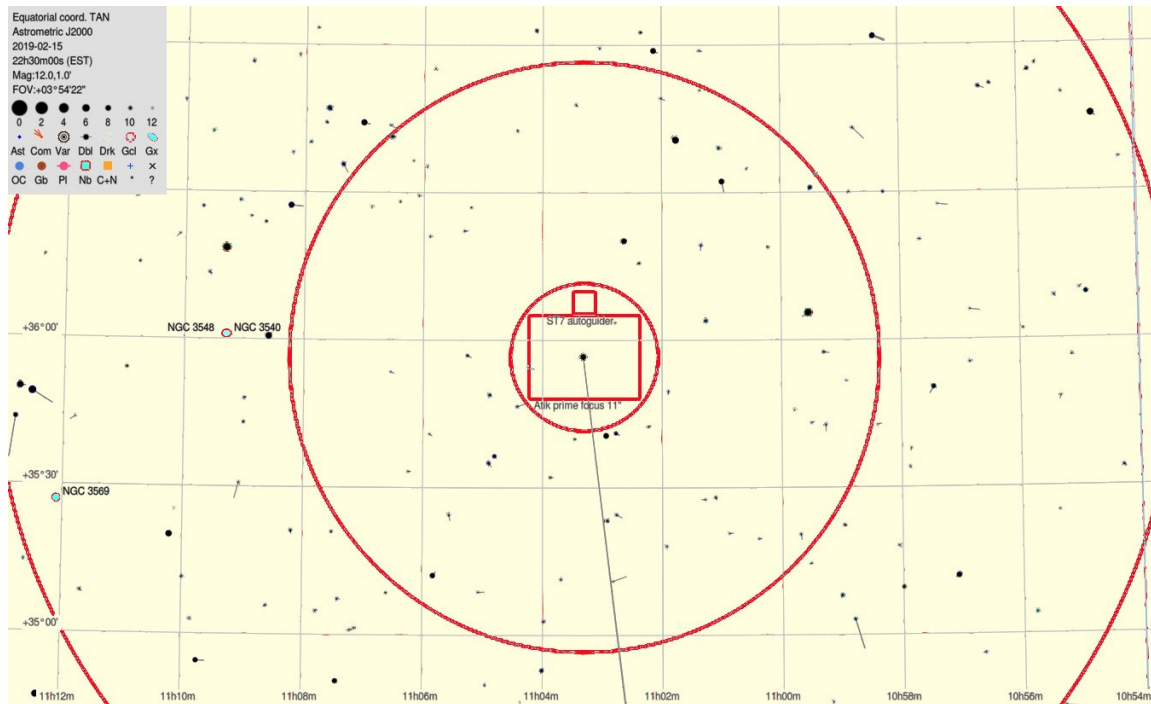


Figure 2: Skychart finder for Lalande 21185 showing proper motion vectors for the next 1000 years. The coordinate grid is Equinox J2000 while the position of Lalande 21185 is Epoch 2019.13.

Figure 2 (above), except with a dark sky background. (The PM vectors can be added under Setup - Display - Lines.)

6. In Skychart, right click on HD 95735. In the pop-up menu, select Telescope → slew.

This should slew the telescope to Lalande 21185.

7. Equip the telescope with the Atik 383L+ CCD camera (if it is not already attached). This camera has a 2-inch outer diameter barrel that will fit in the eyepiece end of the telescope (cassegrain focus), or on the white apochromatic refractor (the “apo”). In both cases, a 2-inch to 1.25-inch converter has to be removed. For optimum spatial resolution, the prime focus of the 11-inch Celestron is used, but for comparison with the position of the star in the past, the PM is so great that the apo may be better for its wider field of view. The thumb screws cannot be trusted to hold the Atik in place so we also use a white cord to secure it to the small white telescope in case it falls. The Atik requires two USB connections (one for filterwheel, one for the red camera) and two power connections.
8. Connect to the Atik from the Dell computer. (Use the right hand Dell for the 11-inch.) Start up “Artemis” for controlling the Atik. Click the “connect” buttons for the camera and the filterwheel.
9. The Atik camera will need to be focused and oriented. Focussing is done by looping short (~1sec) exposures while adjusting the focus knob at the telescope. You watch the images appear on the TV screen and try to make the stars as small as possible. It is also good to have the CCD turned so that the x and y axes of the pixels align roughly with the RA and DEC axes of the sky. Again take ~1-3 sec exposures while moving the telescope (at slow speed, ~8xsidereal rate) left-right (for RA) and up-down (for DEC) until the trailing stars are roughly horizontal or vertical.
10. Take exposures of the high PM star. The R filter is most sensitive. B, G, and R filter images can be later combined to make a color image (optional).
11. You should confirm the *pixel scale* (in arcsec/pix) of the Atik CCD image. Identify low- proper motion stars in both the Atik image and the Skychart screen. In Skychart, click on the “Distance Measurement” icon. Then left-click on one star and drag to another. There is a read-out in the bottom left corner showing you the angular separation in deg, arcminutes and arcseconds.
Stars chosen for scale measurement: _____
Angle between the stars: _____ Convert to arcseconds: _____
Now measure the distance between those stars in the Atik image, in pixels. This can be done by measuring the (x,y) coordinates of each star, taking the differences ($y_2 - y_1$, $x_2 - x_1$), and then applying the Pythagorean theorem ($D^2 = (y_2 - y_1)^2 + (x_2 - x_1)^2$).
Distance between stars (in pixels): $D =$ _____ pixels.
Pixel scale for your CCD image: _____ arcsec/pixel.
12. Use Figure 3 to draw and label the current position of Lalande. The brightest star in this image is Lalande in 1953.
13. On the FITS image of Lalande taken with the Atik CCD, try to find the (x,y) coordinate of Lalande both on the current date and in 1953 (by comparing with Figure 3).
14. Estimate the proper motion components of Lalande, μ_{RA} and μ_{DEC} , using the (x,y) coordinates from the previous step. Show your work in the blue box below.

Calculate μ_{RA} and μ_{DEC} here:

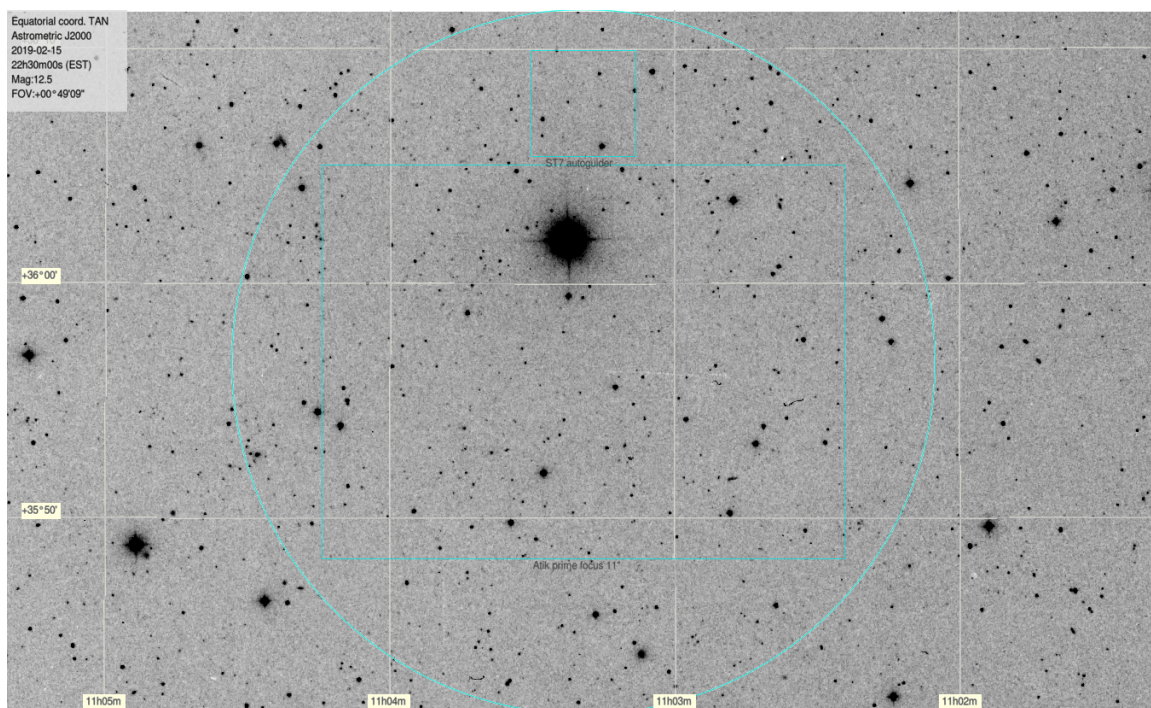


Figure 3: Negative of a DSS image of the field around Lalande (the bright star) taken in Epoch 1953.35.

Info about your CCD image...

Target: _____
 Alt./Azim: _____
 Date/Time: _____
 Telescope: _____ f/ _____
 CCD: _____ Frame _____
 Pix Format: _____ Texp: _____ sec
 Filter: ____ Weather: _____