Feature Articles
Article de fond

A Star Hopping Primer[1]

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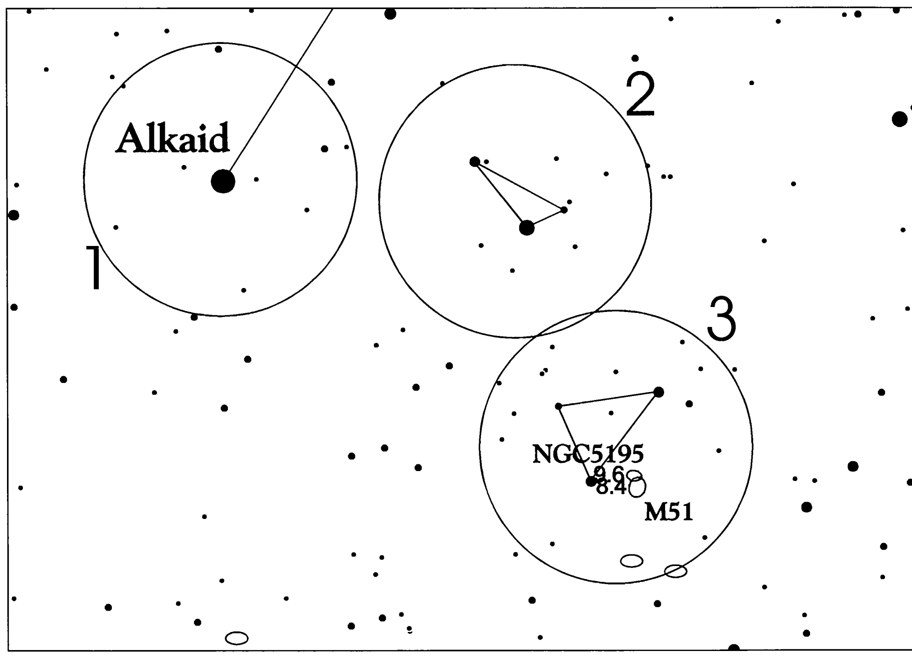
Star hopping is a method used by amateur astronomers to locate objects in the heavens. Star hopping is typically used for finding deep-sky objects, although it is just as effective for tracking down asteroids, comets, variable stars, and anything else in the sky that is too faint to be seen readily by the unaided eye or in a finder scope. For all owners of LX200s and other computerized telescopes, put down your keypad and turn off your digital setting circles. Star hopping is the best way to familiarize oneself with the sky.

Star hopping involves "hopping" from star to star with your telescope, until you arrive at the location of the target object. Your starting point and end point are crucial to determining your "hopping path," and not unlike a car trip across a city, there are many paths that could be followed. Although one wants to take the shortest and simplest path, there are times when that approach is not possible owing to a lack of reasonably bright stars to follow. That may come as a surprise, but there are many areas of the sky that are devoid of sufficiently bright stars (tenth magnitude or brighter) when looking through a small telescopic field of view. If there are not enough stars to guide one to the target, it is very easy to get disoriented and "lose one's place" in the sky. The opposite is also true; if there are too many stars, it can get very confusing because it is difficult to create easily recognizable star patterns. A perfect example is the Milky Way area between Deneb and Albireo in Cygnus, where several dozen stars are visible within a small telescopic field of view. If a simple path is not readily evident, one will have to take "the scenic route" to arrive at the object of interest. That may take longer and involve more steps, but it is a good tradeoff if one can be assured of finding the object.



To star hop to M51, the Whirlpool Galaxy, you might begin at Alkaid (the star at the end of the Big Dipper's handle) in field 1, then hop west to the small triangle at field 2, and then find the triangle in field 3 by moving at right angles to the shortest segment of the 1st triangle. M51 is then found adjacent to the brighter two stars of the 2nd triangle. (ECU Chart by Dave Lane)

In the sections below I describe the basic equipment required for star hopping, as well as a few tips and hints that should make searches easier.

Star Atlases: The More Stars, the Merrier

A good star atlas must show enough faint stars to be useful for a star-hopping trek. I recommend, as a minimum, *Sky Atlas 2000.0*. The latest edition of the atlas shows stars to magnitude 8.5 (a total of 81,312 stars), and its oversized (9″× 22″) pages often show entire constellations on one chart, making it easier to relate what is seen on paper to what is in the sky. I highly recommend the desk edition, which shows black stars on white paper. The field edition shows white stars on black paper and is actually much more difficult to use in the dark with a red flashlight. Furthermore, the desk edition allows the possibility of writing small notes, adding objects, or plotting comet positions, because the paper is white. One last suggestion: use a pencil (or a thin permanent marker if your atlas is

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already laminated) to add the basic constellation lines to the maps. For example, "connect the dots" in Ursa Major to form the Big Dipper, connect the stars in Sagittarius to form the "teapot," and connect the stars in Orion to form the hunter's body. That should be a great help in allowing one to find one's way quickly around a map, and ultimately the sky. If the main objective is deep sky observing, the sky atlas should also include as many deep sky objects as possible. *Sky Atlas 2000.0* is a good intermediate atlas in that regard, displaying over 2,500 deep sky objects.

The next best atlas is *Uranometria 2000.0*. Once one graduates from the Messier list and the brighter NGC objects, the *Uranometria* is essential, because many faint deep sky objects are not plotted in *Sky Atlas 2000.0*. Uranometria comes in two thick volumes that display stars to magnitude 9.5 (for a total of 332,000 stars) and a total of 10,300 deep sky objects. Because each chart is just 9″ × 12″, only a small portion of the sky is plotted on one page, so it is useful to use the atlas in conjunction with a larger scale atlas, such as *Sky Atlas 2000.0*.

The ultimate star atlas is the recently published *Millennium Star Atlas*. This three-volume modern work of art includes stars as faint as magnitude 11 (for a total of 1,058,000 stars), and contains over 10,000 deep sky objects. As is the case for *Uranometria*, it is necessary to use a larger scale atlas together with *Millennium* because each 9″ × 13″ chart displays only a very small part of the sky. The main drawback to *Millennium* is its Canadian price tag of $400.

Finder Scopes: The Bigger the Better

A good finder scope with a wide field of view is very important for star hopping. The absolute minimum is a 6×30 finder. An 8×50 finder is much better, and 9×60s are the best. A finder with a field of view of five to seven degrees allows one to zoom into the correct area of the sky quickly by showing many faint stars at once. There will be instances when one is able to use a star atlas and a finder scope to aim one's telescope precisely. Then, just by looking through the main telescope, one will be able to see the target object in the field of view. Many people like using zero-power finders, such as the Telrad, Rigel QuikFinder, or Tele Vue QwikPoint. Although they are extremely useful for aiming a telescope at objects visible to the unaided eye, they are not effective tools for viewing the fainter stars that guide one on a star hop. For the best of both worlds, I highly recommend using both a zero-power finder and an 8×50 (or larger) finder scope.

Wide-Field Eyepieces: Low Power for More Stars

The next tip for successful star hopping is to use an eyepiece that provides the widest possible field of view. The wider one's field of view, the more guide stars one is able to see through the telescope, which in turn makes it easier to hop from star to star. Never star hop at high magnifications since it will only frustrate you. It is best to switch to high power only when one arrives at the target location and is ready to begin small sweeps of the area of interest.

Field of View: How Large is Yours?

An excellent star-hopping aid that one can make at home is an acetate overlay displaying the fields of view for each eyepiece in one's collection as well as that for the finder scope. They can be extremely useful in those instances where there are not enough bright stars available for star hopping. The way to use an acetate overlay is as follows: place the overlay that matches the eyepiece field of view on the sky atlas, then move the acetate towards the target object and count how many fields of view are required to get there. Next, go to the telescope and move it across just as many fields of view as counted. That will put you fairly close to the target area. Now gently sweep back and forth until you spot the target object.

To make such an overlay it is necessary to know the exact field of view of each eyepiece. A quick method for determining that is to aim the telescope at a known part of the sky, then compare what is seen in the eyepiece with what is visible on a star map. Next, use the map's declination markings (shown in degrees) to calculate how much of the sky is seen with the eyepiece. Another method requires two pieces of data: the eyepiece's apparent field of view and its magnification with a given telescope. Here is an example. Suppose you have a 25-mm eyepiece that has a 50-degree apparent field of view, and your telescope is an 8-inch f/10 Schmidt-Cassegrain telescope with a focal length of 2000 mm. The magnification of the eyepiece for that specific telescope is given by the ratio of the focal length of the telescope to the focal length of the eyepiece, *i.e.* 80 (2000 mm ÷ 25 mm). Next take the eyepiece's apparent field of view and divide by the magnification, which gives the actual field of view, in this case 0°.625 (50° ÷ 80). If you do not know the apparent field of view of your eyepieces, check the ads in astronomy magazines for the same eyepiece, since they often state the value, or check with a telescope dealer, or visit the eyepiece manufacturer's web site.

The most accurate method for determining an eyepiece's field of view is to time how long it takes a star to cross the field of view. Start by aiming the telescope at any star that is within 10 degrees of the celestial equator. Place the star at the edge of the field of view, then turn off the telescope drive (if you have one) and use a stopwatch to time how long it takes for the star to cross the entire field of view. To calculate the field of view, multiply the time (in seconds) by 15 to obtain the field dimension in arcseconds. For wider field eyepieces, multiply the time in minutes by 15 to obtain the field dimension in arcminutes. The calculations are derived from the fact that a star near the celestial equator moves one degree every four minutes.

With knowledge of the fields of view of one's eyepieces, the overlays can be created by simply drawing circles of the corresponding sizes on an overhead projector acetate using a permanent marker. If the equipment is available, you can use a computer and a laser printer to print circles right on the acetate. Note that a different overlay is needed for each sky atlas, since the charts have different scales. [The ability to make such overlays is another advantage to using the desk edition of the *Sky Atlas 2000.0*; with the field edition you can make holes of the right size in a piece of cardboard, but it is more awkward to use.]

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Inverted and Reversed Images: Weren't We Supposed to Turn Left at Epsilon Eridani?

Depending upon what type of telescope one has and the accessories used with it, what is seen through the eyepiece is generally an image that is inverted (upside-down), or inverted and reversed (mirrored). Most of us are aware of the confusion that can lead to! As a rule of thumb, keep in mind that an even number of reflections result in an inverted image (*e.g.* a Newtonian telescope where the primary and secondary mirrors result in two reflections). An odd number of reflections result in an inverted and reversed image (*e.g.* a Schmidt-Cassegrain telescope where the primary, secondary, and star diagonal mirrors result in three reflections, or a refractor with a star diagonal, since that amounts to one reflection).

Inverted views in the telescope are easy to cope with — simply turn the sky atlas upside down to match what is seen in the eyepiece. There is unfortunately no easy solution for reversed images. It is possible to train yourself to always remember that whatever is seen on a star map is reversed in the eyepiece. It is not too difficult to master, but if similar star patterns are evident on either side of the target object, things can get very confusing and it is possible to star hop in the wrong direction. Another solution is to flip the sky chart and to illuminate it from behind using a light. That works only if the paper is not too thick and if the map is printed only on one side, such as in *Sky Atlas 2000.0*. The trick will not work with *Uranometria* or *Millennium* since they have printing on both sides of each sheet. If a reversed view is causing serious troubles, temporarily remove the star diagonal from your Schmidt-Cassegrain or refracting telescope. Drawbacks to that solution are the need to extensively turn the focussing knob to reach focus, and possibly uncomfortable viewing caused by the eyepiece being in an awkward position.

Sky Directions: I Thought That Way Was West

Suppose you are looking for a galaxy that is just a couple of degrees north of a star you are viewing. You know you have to move your telescope north, but you just cannot figure out which way that is when looking through the eyepiece. Should the star in the field of view disappear towards the top or bottom of the eyepiece as you move your telescope towards the target galaxy? It depends upon many factors — telescope type, whether you are using a star diagonal, and the orientation of your eye. The method I use is to simply nudge the telescope tube up (i.e. north) without worrying about which way the stars move in the eyepiece. This works perfectly each time, assuming your telescope is equatorially mounted. If you are using an alt-azimuth mount, the method may still work depending on which part of the sky you are observing, but remember that will have to make a slight adjustment is azimuth. The same method will work for east or west movements. If your target is east of your current location, just move the telescope to the left, and if it is to the west, move your instrument to the right. Again, this assumes an equatorially mounted telescope, but it may still work with an alt-azimuth mount, depending on which part of the sky you are observing, by just making a small adjustment in altitude. I like the method because I find it easy to relate what I see in an atlas to the sky. For example, the globular cluster M15 is to the right of Epsilon Pegasi, as seen in a sky map. My star hopping path would be to start by aiming the telescope at Epsilon then slowly move my telescope right until I find M15.

Such a trick works just fine when one is facing east, south, or west, but what happens when one is facing north? In some instances it becomes more difficult to match the atlas directions to directions in the sky. If you are facing north and need to move the telescope to the west, you should still move it to the right. It will appear as if you are actually moving it towards the eastern horizon, but in fact you are moving it west. Another way to look at it is as follows. A motor driven telescope moves from east to west (left to right) no matter which way the telescope is pointing, so left is always east and right is always west. This may be a rather unorthodox methodology since most observing books and articles will teach you to always think in terms of east, west, north, and south. The method used here for determining which way to move the telescope (left, right, up, and down) has never failed me, however.

Although the method outlined above is primarily for equatorially mounted telescopes, there will be many instances where it will also be effective with an alt-azimuth mount. Remember that the required "slight adjustments" mentioned above will become increasingly large as you observe areas of the sky further away from the meridian/celestial equator. An excellent method for regaining your bearings if you are "lost in space" with your alt-azimuth mounted telescope is to nudge your telescope tube towards Polaris. New stars will enter the field from the north side of your field of view. You