CHAPTER II

IN THE STARRY HEAVENS

"Now constellations, Muse, and signs rehearse;
In order let them sparkle in thy verse."--MANILIUS.

Let us imagine ourselves the happy possessors of three properly mounted telescopes of five, four, and three inches aperture, respectively. A fine midwinter evening has come along, the air is clear, cool, and steady, and the heavens, of that almost invisible violet which is reserved for the lovers of celestial scenery, are spangled with stars that hardly twinkle. We need not disturb our minds about a few thin clouds here and there floating lazily in the high air; they announce a change of weather, but they will not trouble us to-night.

Which way shall we look? Our eyes will answer the question for us. However we may direct them, they instinctively return to the south, and are lifted to behold Orion in his glory, now near the meridian and midway to the zenith, with Taurus shaking the glittering Pleiades before him, and Canis Major with the flaming Dog Star following at his heels.

Not only is Orion the most brilliant of all constellations to the casual star-gazer, but it contains the richest mines that the delver for telescopic treasures can anywhere discover. We could not have made a

better beginning, for here within a space of a few square degrees we have a wonderful variety of double stars and multiple stars, so close and delicate as to test the powers of the best telescopes, besides a profusion of star-clusters and nebulæ, including one of the supreme marvels of space, the Great Nebula in the Sword.

Our star map No. 1 will serve as a guide to the objects which we are about to inspect. Let us begin operations with our smallest telescope, the three-inch. I may remark here that, just as the lowest magnifying power that will clearly reveal the object looked for gives ordinarily better results than a higher power, so the smallest telescope that is competent to show what one wishes to see is likely to yield more satisfaction, as far as that particular object is concerned, than a larger glass. The larger the object glass and the higher the power, the greater are the atmospheric difficulties. A small telescope will perform very well on a night when a large one is helpless.

Turn the glass upon beta (Rigel), the white first-magnitude star in Orion's left foot. Observe whether the image with a high power is clear, sharp, and free from irregular wisps of stray light. Look at the rings in and out of focus, and if you are satisfied with the performance, try for the companion. A good three-inch is certain to show it, except in a bad state of the atmosphere, and even then an expert can see it, at least by glimpses. The companion is of the ninth magnitude, some say the eighth, and the distance is about 9.5", angle of position (hereafter designated by p.) 199°.[1] Its color is blue, in decided contrast with

the white light of its great primary. Sir John Herschel, however, saw the companion red, as others have done. These differences are doubtless due to imperfections of the eye or the telescope. In 1871 Burnham believed he had discovered that the companion was an exceedingly close double star. No one except Burnham himself succeeded in dividing it, and he could only do so at times. Afterward, when he was at Mount Hamilton, he tried in vain to split it with the great thirty-six-inch telescope, in 1889, 1890, and 1891. His want of success induced him to suggest that the component stars were in rapid motion, and so, although he admitted that it might not be double after all, he advised that it should be watched for a few years longer. His confidence was justified, for in 1898 Aitken, with the Lick telescope, saw and measured the distance of the extremely minute companion--distance 0.17", p. 177°.

[1] The angle of position measures the inclination to the meridian of a line drawn between the principal star and its companion; in other words, it shows in what direction from the primary we must look for the companion. It is reckoned from 0° up to 360°, beginning at the north point and passing around by east through south and west to north again. Thus, if the angle of position is 0° or 360°, the companion is on the north side of the primary; if the angle is 90°, the companion is to the east; if 180°, to the south; if 270°, to the west, and so for intermediate angles. It must be remembered, however, that in the field of the telescope the top is south and the bottom north, unless a prism is used, when directions become complicated. East and west can be

readily identified by noticing the motion of a star through the field; it moves toward the west and from the east.

Rigel has been suspected of a slight degree of variability. It is evidently a star of enormous actual magnitude, for its parallax escapes trustworthy measurement. It can only be ranked among the very first of the light-givers of the visible universe. Spectroscopically it belongs to a peculiar type which has very few representatives among the bright stars, and which has been thus described: "Spectra in which the hydrogen lines and the few metallic lines all appear to be of equal breadth and sharp definition." Rigel shows a line which some believe to represent magnesium; but while it has iron lines in its spectrum, it exhibits no evidence of the existence of any such cloud of volatilized iron as that which helps to envelop the sun.

For another test of what the three-inch will do turn to zeta, the lower, or left-hand, star in the Belt. This is a triple, the magnitudes being second, sixth, and tenth. The sixth-magnitude star is about 2.5" from the primary, p. 149°, and has a very peculiar color, hard to describe. It requires careful focusing to get a satisfactory view of this star with a three-inch telescope. Use magnifying powers up to two hundred and fifty diameters. With our four-inch the star is much easier, and the five-inch shows it readily with a power of one hundred. The tenth-magnitude companion is distant 56", p. 8°, and may be glimpsed with the three-inch. Upon the whole, we shall find that we get more pleasing views of zeta Orionis with the four-inch glass.

Just to the left of zeta, and in the same field of view with a very low power, is a remarkable nebula bearing the catalogue number 1227. We must use our five-inch on this with a low power, but with zeta out of the field in order to avoid its glare. The nebula is exceedingly faint, and we can be satisfied if we see it simply as a hazy spot, although with much larger telescopes it has appeared at least half a degree broad. Tempel saw several centers of condensation in it, and traced three or four broad nebulous streams, one of which decidedly suggested spiral motion.

The upper star in the Belt, delta, is double; distance, 53", p. 360°; magnitudes, second and seventh very nearly; colors, white and green or blue. This, of course, is an easy object for the three-inch with a low magnifying power. It would be useless to look for the two fainter companions of delta, discovered by Burnham, even with our five-inch glass. But we shall probably need the five-inch for our next attempt, and it will be well to put on a high power, say three hundred diameters. The star to be examined is the little brilliant dangling below the right-hand end of the Belt, toward Rigel. It appears on the map as eta. Spare no pains in getting an accurate focus, for here is something worth looking at, and unless you have a trained eye you will not easily see it. The star is double, magnitudes third and sixth, and the distance from center to center barely exceeds 1", p. 87°. A little tremulousness of the atmosphere for a moment conceals the smaller star, although its presence is manifest from the peculiar jutting of light on one side of

the image of the primary. But in an instant the disturbing undulations pass, the air steadies, the image shrinks and sharpens, and two points of piercing brightness, almost touching one another, dart into sight, the more brilliant one being surrounded by an evanescent circle, a tiny ripple of light, which, as it runs round the star and then recedes, alternately embraces and releases the smaller companion. The wash of the light-waves in the atmosphere provokes many expressions of impatience from the astronomer, but it is often a beautiful phenomenon nevertheless.

Between eta and delta is a fifth-magnitude double star, Sigma 725, which is worth a moment's attention. The primary, of a reddish color, has a very faint star, eleventh magnitude, at a distance of 12.7", p. 88°.

Still retaining the five-inch in use, we may next turn to the other end of the Belt, where, just under zeta, we perceive the fourth-magnitude star sigma. He must be a person of indifferent mind who, after looking with unassisted eyes at the modest glimmering of this little star, can see it as the telescope reveals it without a thrill of wonder and a cry of pleasure. The glass, as by a touch of magic, changes it from one into eight or ten stars. There are two quadruple sets three and a half minutes of arc apart. The first set exhibits a variety of beautiful colors. The largest star, of fourth magnitude, is pale gray; the second in rank, seventh magnitude, distance 42", p. 61°, presents a singular red, "grape-red" Webb calls it; the third, eighth magnitude, distance 12", p. 84°, is blue; and the fourth, eleventh magnitude, distance 12",

p. 236°, is apparently white. Burnham has doubled the fourth-magnitude star, distance 0.23". The second group of four stars consists of three of the eighth to ninth magnitude, arranged in a minute triangle with a much fainter star near them. Between the two quadruple sets careful gazing reveals two other very faint stars. While the five-inch gives a more satisfactory view of this wonderful multiple star than any smaller telescope can do, the four-inch and even the three-inch would have shown it to us as a very beautiful object. However we look at them, there is an appearance of association among these stars, shining with their contrasted colors and their various degrees of brilliance, which is significant of the diversity of conditions and circumstances under which the suns and worlds beyond the solar walk exist.

From sigma let us drop down to see the wonders of Orion's Sword displayed just beneath. We can use with advantage any one of our three telescopes; but since we are going to look at a nebula, it is fortunate that we have a glass so large as five inches aperture. It will reveal interesting things that escape the smaller instruments, because it grasps more than one and a half times as much light as the four-inch, and nearly three times as much as the three-inch; and in dealing with nebulæ a plenty of light is the chief thing to be desired. The middle star in the Sword is theta, and is surrounded by the celebrated Nebula of Orion. The telescope shows theta separated into four stars arranged at the corners of an irregular square, and shining in a black gap in the nebula. These four stars are collectively named the Trapezium. The brightest is of the sixth magnitude, the others are of the seventh,

seven and a half, and eighth magnitudes respectively. The radiant mist about them has a faint greenish tinge, while the four stars, together with three others at no great distance, which follow a fold of the nebula like a row of buttons on a coat, always appear to me to show an extraordinary liveliness of radiance, as if the strange haze served to set them off.

Our three-inch would have shown the four stars of the Trapezium perfectly well, and the four-inch would have revealed a fifth star, very faint, outside a line joining the smallest of the four and its nearest neighbor. But the five-inch goes a step farther and enables us, with steady gazing to see even a sixth star, of only the twelfth magnitude, just outside the Trapezium, near the brightest member of the quartet. The Lick telescope has disclosed one or two other minute points of light associated with the Trapezium. But more interesting than the Trapezium is the vast cloud, full of strange shapes, surrounding it. Nowhere else in the heavens is the architecture of a nebula so clearly displayed. It is an unfinished temple whose gigantic dimensions, while exalting the imagination, proclaim the omnipotence of its builder. But though unfinished it is not abandoned. The work of creation is proceeding within its precincts. There are stars apparently completed, shining like gems just dropped from the hand of the polisher, and around them are masses, eddies, currents, and swirls of nebulous matter yet to be condensed, compacted, and constructed into suns. It is an education in the nebular theory of the universe merely to look at this spot with a good telescope. If we do not gaze at it long and wistfully, and return

to it many times with unflagging interest, we may be certain that there is not the making of an astronomer in us.

Before quitting the Orion nebula do not fail to notice an eighth-magnitude star, a short distance northeast of the Great Nebula, and nearly opposite the broad opening in the latter that leads in toward the gap occupied by the Trapezium. This star is plainly enveloped in nebulosity, that is unquestionably connected with the larger mass of which it appears to form a satellite.

At the lower end of the Sword is the star iota, somewhat under the third magnitude. Our three-inch will show that it has a bluish companion of seventh or eighth magnitude, at a little more than 11" distance, p. 142°, and the larger apertures will reveal a third star, of tenth magnitude, and reddish in color, distance 49", p. 103°. Close by iota we find the little double star Sigma 747, whose components are of five and a half and six and a half magnitudes respectively, and separated 36", p. 223°. Above the uppermost star in the Sword is a small star cluster, No. 1184, which derives a special interest from the fact that it incloses a delicate double star, Sigma 750, whose larger component is of the sixth magnitude, while the smaller is of the ninth, and the distance is only 4.3", p. 59°. We may try the four-inch on this object.

Having looked at alpha (Betelgeuse), the great topaz star on Orion's right shoulder, and admired the splendor of its color, we may turn the four-inch upon the star Sigma 795, frequently referred to by its number

as "52 Orionis." It consists of one star of the sixth and another of sixth and a half magnitude, only 1.5" apart, p. 200°. Having separated them with a power of two hundred and fifty diameters on the four-inch, we may try them with a high power on the three-inch. We shall only succeed this time if our glass is of first-rate quality and the air is perfectly steady.

The star lambda in Orion's head presents an easy conquest for the three-inch, as it consists of a light-yellow star of magnitude three and a half and a reddish companion of the sixth magnitude; distance 4", p. 43°. There is also a twelfth-magnitude star at 27", p. 183°, and a tenth or eleventh magnitude one at 149", p. 278°. These are tests for the five-inch, and we must not be disappointed if we do not succeed in seeing the smaller one even with that aperture.

Other objects in Orion, to be found with the aid of our map, are: Sigma 627, a double star, magnitude six and a half and seven, distance 21", p. 260°; Omicron Sigma 98, otherwise named iota Orionis, double, magnitude six and seven, distance 1", p. 180°, requires five-inch glass; Sigma 652, double, magnitudes six and a half and eight, distance 1.7", p. 184°; rho, double, magnitudes five and eight and a half, the latter blue, distance 7", p. 62°, may be tried with a three-inch; tau, triple star, magnitudes four, ten and a half, and eleven, distances 36", p. 249°, and 36", p. 60°. Burnham discovered that the ten-and-a-half magnitude star is again double, distance 4", p. 50°. There is not much satisfaction in attempting tau Orionis with telescopes of ordinary

apertures; Sigma 629 otherwise m Orionis, double, magnitudes five and a half (greenish) and seven, distance 31.7", p. 28°, a pretty object; Sigma 728, otherwise A 32, double, magnitudes five and seven, distance, 0.5" or less, p. 206°, a rapid binary,[2] which is at present too close for ordinary telescopes, although it was once within their reach; Sigma 729, double, magnitudes six and eight, distance 2", p. 26°, the smaller star pale blue--try it with a four-inch, but five-inch is better; Sigma 816, double, magnitudes six and half and eight and a half, distance 4", p. 289°; psi 2, double, magnitudes five and a half and eleven, distance 3", or a little less, p. 322°; 905, star cluster, contains about twenty stars from the eighth to the eleventh magnitude; 1267, nebula, faint, containing a triple star of the eighth magnitude, two of whose components are 51" apart, while the third is only 1.7" from its companion, p. 85°; 1376, star cluster, small and crowded; 1361, star cluster, triangular shape, containing thirty stars, seventh to tenth magnitudes, one of which is a double, distance 2.4".

[2] The term "binary" is used to describe double stars which are in motion about their common center of gravity.

Let us now leave the inviting star-fields of Orion and take a glance at the little constellation of Lepus, crouching at the feet of the mythical giant. We may begin with a new kind of object, the celebrated red variable R Leporis (map No. 1). This star varies from the sixth or seventh magnitude to magnitude eight and a half in a period of four hundred and twenty-four days. Hind's picturesque description of its

color has frequently been quoted. He said it is "of the most intense crimson, resembling a blood-drop on the black ground of the sky." It is important to remember that this star is reddest when faintest, so that if we chance to see it near its maximum of brightness it will not impress us as being crimson at all, but rather a dull, coppery red. Its spectrum indicates that it is smothered with absorbing vapors, a sun near extinction which, at intervals, experiences an accession of energy and bursts through its stifling envelope with explosive radiance, only to faint and sink once more. It is well to use our largest aperture in examining this star.

We may also employ the five-inch for an inspection of the double star iota, whose chief component of the fifth magnitude is beautifully tinged with green. The smaller companion is very faint, eleventh magnitude, and the distance is about 13", p. 337°.

Another fine double in Lepus is kappa, to be found just below iota; the components are of the fifth and eighth magnitudes, pale yellow and blue respectively, distance 2.5", p. 360°; the third-magnitude star alpha has a tenth-magnitude companion at a distance of 35", p. 156°, and its neighbor beta (map No. 2), according to Burnham, is attended by three eleventh-magnitude stars, two of which are at distances of 206", p. 75°, and 240", p. 58°, respectively, while the third is less than 3" from beta, p. 288°; the star gamma (map No. 2) is a wide double, the distance being 94", and the magnitudes four and eight. The star numbered 45 is a remarkable multiple, but the components are too faint to possess much

interest for those who are not armed with very powerful telescopes.

From Lepus we pass to Canis Major (map No. 2). There is no hope of our being able to see the companion of alpha (Sirius), at present (1901), even with our five-inch. Discovered by Alvan Clark with an eighteen-inch telescope in 1862, when its distance was 10" from the center of Sirius, this ninth-magnitude star has since been swallowed up in the blaze of its great primary. At first, it slightly increased its distance, and from 1868 until 1879 most of the measures made by different observers considerably exceeded 11". Then it began to close up, and in 1890 the distance scarcely exceeded 4". Burnham was the last to catch sight of it with the Lick telescope in that year. After that no human eye saw it until 1896, when it was rediscovered at the Lick Observatory. Since then the distance has gradually increased to nearly 5". According to Burnham, its periodic time is about fifty-three years, and its nearest approach to Sirius should have taken place in the middle of 1892. Later calculations reduce the periodic time to forty-eight or forty-nine years. If we can not see the companion of the Dog Star with our instruments, we can at least, while admiring the splendor of that dazzling orb, reflect with profit upon the fact that although the companion is ten thousand times less bright than Sirius, it is half as massive as its brilliant neighbor. Imagine a subluminous body half as ponderous as the sun to be set revolving round it somewhere between Uranus and Neptune. Remember that that body would possess one hundred and sixty-five thousand times the gravitating energy of the earth, and that five hundred and twenty Jupiters would be required to equal its

power of attraction, and then consider the consequences to our easy-going planets! Plainly the solar system is not cut according to the Sirian fashion. We shall hardly find a more remarkable coupling of celestial bodies until we come, on another evening, to a star that began, ages ago, to amaze the thoughtful and inspire the superstitious with dread--the wonderful Algol in Perseus.

We may remark in passing that Sirius is the brightest representative of the great spectroscopic type I, which includes more than half of all the stars yet studied, and which is characterized by a white or bluish-white color, and a spectrum possessing few or at best faint metallic lines, but remarkably broad, black, and intense lines of hydrogen. The inference is that Sirius is surrounded by an enormous atmosphere of hydrogen, and that the intensity of its radiation is greater, surface for surface, than that of the sun. There is historical evidence to support the assertion, improbable in itself, that Sirius, within eighteen hundred years, has changed color from red to white.

With either of our telescopes we shall have a feast for the eye when we turn the glass upon the star cluster No. 1454, some four degrees south of Sirius. Look for a red star near the center. Observe the curving rows so suggestive of design, or rather of the process by which this cluster was evolved out of a pre-existing nebula. You will recall the winding streams in the Great Nebula of Orion. Another star cluster worth a moment's attention is No. 1479, above and to the left of Sirius. We had better use the five-inch for this, as many of the stars are very faint.

Not far away we find the double star , whose components are of the fifth and eighth magnitudes, distance 2.8", p. 343°. The small star is pale blue. Cluster No. 1512 is a pleasing object with our largest aperture. In No. 1511 we have a faint nebula remarkable for the rows of minute stars in and near it. The star gamma is an irregular variable. In 1670 it is said to have almost disappeared, while at the beginning of the eighteenth century it was more than twice as bright as it is to-day. The reddish star delta is also probably variable. In my "Astronomy with an Opera Glass" will be found a cut showing a singular array of small stars partly encircling delta. These are widely scattered by a telescope, even with the lowest power.

Eastward from Canis Major we find some of the stars of Argo Navis. Sigma 1097, of the sixth magnitude, has two minute companions at 20" distance, p. 311° and 312°. The large star is itself double, but the distance, 0.8", p. 166°, places it beyond our reach. According to Burnham, there is yet a fourth faint star at 31", p. 40°. Some three degrees and a half below and to the left of the star just examined is a beautiful star cluster, No. 1551. Nos. 1564, 1571, and 1630 are other star clusters well worth examination. A planetary nebula is included in 1564. With very powerful telescopes this nebula has been seen ring-shaped. Sigma 1146, otherwise known as 5 Navis, is a pretty double, colors pale yellow and blue, magnitudes five and seven, distance 3.25", p. 19°. Our three-inch will suffice for this.

North of Canis Major and Argo we find Monoceros and Canis Minor (map No.

3). The stars forming the western end of Monoceros are depicted on map No. 1. We shall begin with these. The most interesting and beautiful is 11, a fine triple star, magnitudes five, six, and seven, distances 7.4", p. 131°, and 2.7", p. 103°. Sir William Herschel regarded this as one of the most beautiful sights in the heavens. It is a good object to try our three-inch on, although it should not be difficult for such an aperture. The star 4 is also a triple, magnitudes six, ten, and eleven, distances 3.4", p. 178°, and 10", p. 244°. We should glance at the star 5 to admire its fine orange color. In 8 we find a golden fifth-magnitude star, combined with a blue or lilac star of the seventh magnitude, distance 14", p. 24°. Sigma 938 is a difficult double, magnitudes six and a half and twelve, distance 10", p. 210°. Sigma 921 is double, magnitudes six and a half and eight, distance 16", p. 4°. At the spot marked on the map 1424 we find an interesting cluster containing one star of the sixth magnitude.

The remaining stars of Monoceros will be found on map No. 3. The double and triple stars to be noted are S, or Sigma 950 (which is also a variable and involved in a faint nebula), magnitudes six and nine, distance 2.5", p. 206°; Sigma 1183, double, magnitudes five and a half and eight, distance 31", p. 326°; Sigma 1190, triple, magnitudes five and a half, ten, and nine, distances 31", p. 105°, and 67", p. 244°. The clusters are 1465, which has a minute triple star near the center; 1483, one member of whose swarm is red; 1611, very small but rich; and 1637, interesting for the great number of ninth-magnitude stars that it contains. We should use the five-inch for all of these.

Canis Minor and the Head of Hydra are also contained on map No. 3. Procyon, alpha of Canis Minor, has several minute stars in the same field of view. There is, besides, a companion which, although it was known to exist, no telescope was able to detect until November, 1896. It must be of immense mass, since its attraction causes perceptible perturbations in the motion of Procyon. Its magnitude is eight and a half, distance 4.83", p. 338°. One of the small stars just referred to, the second one east of Procyon, distant one third of the moon's diameter, is an interesting double. Our four-inch may separate it, and the five-inch is certain to do so. The magnitudes are seven and seven and a half or eight, distance 1.2", p. 133°. This star is variously named Sigma 1126 and 31 Can. Min. Bode. Star No. 14 is a wide triple, magnitudes six, seven, and eight, distances 75, p. 65°, and 115", p. 154°.

PROCYON AND ITS NEIGHBORS.

In the Head of Hydra we find Sigma 1245, a double of the sixth and seventh magnitudes, distance 10.5", p. 25°. The larger star shows a fine yellow. In epsilon we have a beautiful combination of a yellow with a blue star, magnitudes four and eight, distance 3.4", p. 198°. Finally, let us look at theta for a light test with the five-inch. The two stars composing it are of the fourth and twelfth magnitudes, distance 50", p. 170°.

The brilliant constellations of Gemini and Taurus tempt us next, but warning clouds are gathering, and we shall do well to house our telescopes and warm our fingers by the winter fire. There will be other bright nights, and the stars are lasting.