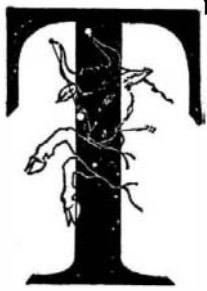


THE HEAVENS IN DECEMBER.

BY HENRY NORRIS RUSSELL, PH.D.



THE prediction of the return of a periodic comet involves a number of difficulties which are not met with in similar calculations concerning the planets. Comets, especially those of long period, move in very elongated ellipses, and can be observed only when relatively near the sun, since at great distances they are too faint to be detected. We have therefore to determine the form and dimensions of the orbit from an "observed arc" which may be only one-tenth or one-twentieth of the whole.

A very small error in the observed positions—which may easily occur, especially for a comet which has no sharply defined nucleus—may thus lead to a much greater uncertainty in the calculated dimensions of the orbit, and the resulting time of the next return.

In much the same way a small change in the direction or rate of the comet's motion, such as may be caused by the attraction of a planet near which it comes, may lead to considerable changes in its period, and in the other elements of its orbit. These changes, unlike the effect of observational error, may be accurately calculated, though only by very laborious processes.

When a comet has been observed at two or more returns the influence of observational errors is greatly diminished, and its future behavior, or its past history, can be determined with a high degree of accuracy.

It is thus possible to utilize the ancient chronicles of astronomical events, which have been preserved in various parts of Europe and also in China, and to see whether earlier relics of the body under investigation can be identified.

It is of course insufficient to find the mere statement that a comet was seen in a certain year, for there are many cases on record when two comets were visible within that interval. We need specific information from which the comet's apparent place in the heavens at a known date can be inferred. If this agrees with our calculations, or, at least, does not depart from them more than is reasonable to attribute to the errors of naked-eye observations and rough descriptions, the identity of the comet is assured.

This procedure has been adopted by Messrs. Cowell and Crommelin, of the Greenwich Observatory, whose work is noteworthy no less for its practical ingenuity, from the standpoint of the calculator, than for its signal success.

Working backward from the last return in 1835, they found returns in 1759, 1682, 1607, 1531, 1456, and 1378 already definitely established by the work of preceding astronomers. Those of the sixteenth and seventeenth centuries were the basis of Halley's notable discovery of the periodicity of the comet, which causes it to bear his name. The next previous return should have occurred on October 26th, A. D. 1301, only four days later than the date deduced by Hind from the Chinese observations of a comet in that year. The difference is quite within the errors of such rough estimates of position. It is noteworthy that the European observations (or at least the existing records) of the same comet are much less accurate than the Chinese—a curious reversal of the present state of things. Still working backward, the returns of the comet in the years 1222, 1145, 1066 (a famous comet which appeared just before the Norman Conquest of England) and 989 can be identified in the chronicles.

At the preceding perihelion passage in 912 there are vague references to a comet or comets, in addition to a bright one which appeared some four months earlier than Halley's could have done, but nothing sufficiently precise for identification. On the other hand, the

return in 837 is well described, and that in 760 was recorded by the Chinese with sufficient detail to enable M. Laugier many years ago to show from the observations alone that the orbit of this comet, in its visible portion, was practically the same as that of Halley's comet.

The return of A. D. 684 was observed in China and Japan. In 607 at least two comets appeared, one of which was doubtless the object of our study. The apparition in 530 is again definitely identified, and the Chinese observations of 451 are by themselves conclusive as to the comet's identity.

Even here the end is not reached. The returns of A. D. 373, 295, 218, 141, and 66, all appear to have been observed and also those in B. C. 12 and B. C. 87. A comet observed in China in 240 B. C. was probably a still earlier return. Beyond this there are no sufficiently definite observations, though a record of a comet seen in B. C. 467 may perhaps refer to a still earlier apparition.

This is an impressive record, which may well give rise to reflection—on the indefatigable energy of the computers, and not less on the remarkable care of the ancient star-gazers and of the scribes who preserved their records. But from the standpoint of general interest, it is most of all noteworthy that the

Deneb, in Cygnus. The lonely star far down in the southwest is Fomalhaut.

Above this the southern and western sky boasts no very bright stars, but the planets Mars and Saturn are there, close together, in Pisces.

The finest group of all is in the southeast. Low down, and twinkling violently in the winter air, is the splendid Sirius. Above him is Orion which boasts two stars of the first magnitude—Rigel on the right and the ruddy Betelgeux on the left. Due east, and low down, is the lesser Dog-star Procyon. Above on the left are the twin stars Castor and Pollux, and higher still is the brilliant Capella. Across the Milky Way from the last is Aldebaran, the brightest of the stars of Taurus.

This fine constellation, which is shown in our initial, is, like Pegasus, supposed to represent only the head and fore-legs of the Bull. The stars β and ζ on the edge of the Milky Way, mark the tips of his horns. Aldebaran is one of his eyes, and the little V-shaped group of the Hyades, of which it forms a part, marks his face, while the Pleiades are in his neck. Like all the animal-figures in the zodiac, the constellation is of very great antiquity.

Of the constellations not already mentioned we may note the vast and faint areas of Eridanus and Cetus in the south, and the familiar forms of the two Bears and the Dragon beneath the Pole, of Perseus, Cassiopeia, and Andromeda high above us, and of Pegasus to the westward.

THE PLANETS.

Mercury is morning star until the 3rd, and later evening star, but is not favorably placed, and can be seen only at the end of the month, when he sets about 5:45 P. M. far to the south of west.

Venus is also evening star, and is very conspicuous. She is at the greatest elongation (apparent distance) from the sun on the 2nd but is then far south and becomes still more prominent as she comes northward. By the end of the month she remains in sight until after 8 P. M. and is very bright.

Mars is in Pisces, and comes to the meridian about 7 P. M. in the middle of the month. He is moving eastward among the stars, toward Saturn, whom he overtakes on the last day of the year, passing about three degrees north of him. By this time he is 90 million miles distant, and only one-eighth as bright as he was in September.

Jupiter is morning star in Virgo, rising about 1 A. M. in the middle of the month.

Saturn is in Pisces, near Mars, from whom he can be distinguished by the yellow color of his

light. Uranus is in Sagittarius and unobservable. Neptune is in Gemini, approaching opposition, and is visible (with sufficient telescopic power) most of the night.

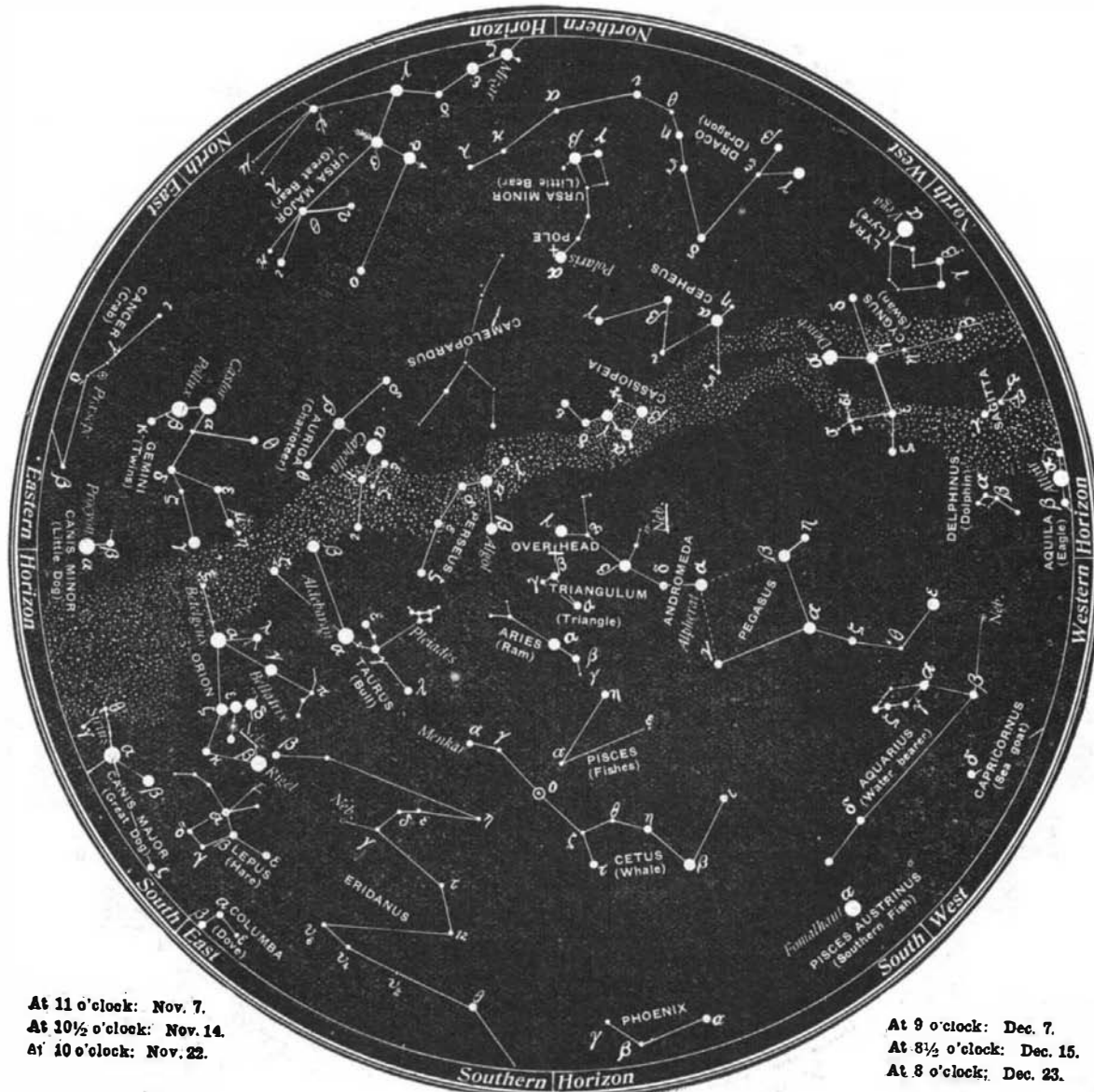
THE MOON.

The moon is in her last quarter at 11 A. M. on the 4th, new at 3 P. M. on the 12th, in her first quarter at 9 P. M. on the 19th, and full at 4 P. M. on the 26th. She is nearest us on the 23rd, and farthest away on the 7th. In her circuit of the sky she passes Jupiter on the 6th, Mercury on the 13th, Uranus on the 14th, Venus on the 16th, Mars on the 20th, Saturn on the 21st, and Neptune on the 27th.

At the present new moon there is a partial eclipse of the sun, which, since it is visible only in New Zealand and the Antarctic regions, is of little account.

Princeton University Observatory.

The Santa Fé Railway Company proposes to electrify the line over Raton Pass for a length of thirty-eight miles, between Trinidad, Colo., and Raton, N. M. For this purpose, says Power, 15,000 electric horse-power will be required for twenty-four hours' consumption in hauling goods and passenger trains through the Rocky Mountains. The change from steam to electricity will involve an expenditure of about \$1,500,000.



NIGHT SKY: NOVEMBER AND DECEMBER

comet has been a conspicuous naked-eye object at at least twenty-four out of its last twenty-six returns, and probably at the other two, where the records are incomplete. We have therefore very good reason to anticipate a fine sight next May, when the comet will be for a few days unusually near us.

At the present apparition, the twenty-fifth which has been certainly observed, the comet is still too faint to be seen without a large telescope, and will remain so until early in the new year. In spite of its faintness, its spectrum has been photographed at the Lick Observatory, showing no trace of bright lines or bands, but only a faint continuous spectrum, such as reflected sunlight would give with the instrument employed.

The awakening of the comet's activity as it approaches the sun had apparently not yet begun. Its progress will be of great interest.

THE HEAVENS.

There is no time in the year when so many of the brightest stars can be seen at once as at present. Looking first to the westward, we find Altair in the constellation of the Eagle, just setting at the hour assigned on our map, but clearly visible a little earlier. Almost due northwest, and a little higher, is Vega, above which is the less brilliant but equally white star