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The Night Sky

A few weeks ago I went out in the late evening, armed with a pair of 7 × 50 binoculars. The sky was almost dark, and beautifully clear. Above me the stars shone down, and when I turned my binoculars toward the lovely cluster of the Seven Sisters I realized, yet again, that to take a real interest in astronomy there is no need to have a powerful telescope.

My own interest in astronomy dates from the age of six, when I picked up a book which happened to be lying around, and began to read it. I was fascinated, and took what I still believe to be the correct steps. I made sure that I could understand the basic facts, and then I equipped myself with an outline star map and started to learn my way around the sky. It did not take nearly so long as I had expected. There are less than three thousand stars visible with the naked eye at any one time, and the constellation patterns never change, so that once you have identified a group there is no real problem in recognizing it again. I found the Great Bear, the Little Bear, the Swan and the Square of Pegasus; when winter came I used Orion, the Hunter, as a guide to other constellations, and before long I could identify the brightest stars with no trouble at all. I could see, too, that they were not all alike. Some were white, while others were distinctly orange-red, and a few were bluish – notably Vega, which is almost overhead from England during summer evenings. Then there were the planets, which looked like stars but which I tracked as they wandered slowly around from one constellation to another. I remember that Venus and Jupiter were both on view, and there was no mistaking them, because they were so brilliant. Next came Mars, identifiable because of its fiery red tint. Saturn was more of a problem; it looked to me like an ordinary star, and it puzzled me for some time because I could not find it on my outline map. I looked at the Moon, and made out the dark patches which we still call 'seas' even though there has never been any water in them. I watched for meteors or shooting-stars dashing across the sky, and within those first few months I was lucky enough to see a display of the Northern Lights – something which is not common from a latitude as far south as that of Sussex where I lived. The more I saw and read, the more my interest grew.

I wanted to make a real hobby out of astronomy. That, I thought, meant obtaining a telescope. I saved up my pocket money, Christmas presents, birthday presents and everything else until I had accumulated the princely sum of £7.10s ($12). That was enough to buy a proper telescope – a refractor with an object-glass three inches (76 millimetres) in diameter. I still have that telescope, and I still use it. With it I learned my way around the Moon, saw the belts and satellites of Jupiter, the rings of Saturn and almost countless star-fields and clusters. I was 'hooked'.

But this was long ago; when I bought my telescope, which must have been in 1933, prices were very different from those of today. Look for a 75-mm refractor now, and you will have to pay something of the order of £600 ($1000), which is more than many people care to spend upon a hobby. Therefore, what often happens is that the would-be enthusiast gives up, and lets his interest in astronomy fade into the background.

Binoculars provide a satisfactory answer. True, they are of low magnification when compared with telescopes, but they will give immense pleasure, and then can even be used for a certain amount of real scientific work; after all, astronomy is still just about the only science in which the amateur can play a useful rôle. There are some specialist observers who use binoculars and nothing else. The cost is comparatively modest. You can probably pick up a reasonable pair of binoculars for £50 ($75) or so, and with £100 ($150) you have a wide choice. Also, most households can muster binoculars of some sort, probably used originally for bird-watching or looking at ships out to sea. Even old-fashioned opera-glasses are not to be despised.

The value of binoculars in astronomy is not widely appreciated, and this book is an attempt to help in putting the record straight. I will not pretend for a moment that binoculars can rival telescopes, but they have their own particular advantages, quite apart from the fact that they can be bought comparatively cheaply.

Before setting out upon a tour of the sky, it is, I think, worth spending a few pages in giving an outline of the basic facts. Most people will know them already (in which case, you have my full permission to skip the rest of this chapter and proceed straight to page 8), but it is as well to be sure. I still come across people who confuse the science of astronomy with the ancient pseudo-science of astrology, which links the movements of the planets with human character and destiny. My comment here is that astrology proves one thing only: 'There's one born every minute!'

The Earth upon which we live is a planet, moving round the Sun at a distance of 150000000 kilometres.* This may sound a long way, but it is not much to an astronomer, who has to become used to dealing with vast distances and immense periods of time. The Sun is a normal star, not nearly so luminous as many of those visible on any clear night. It appears so glorious in our skies simply because, cosmically speaking, it is upon our doorstep. Represent the Earth–Sun distance by 25 millimetres, and the nearest star will be over 6½ kilometres away. The Sun is the centre of the Solar System, which is made up of nine planets (including the Earth), the moons or satellites of the planets, and various bodies of lesser importance such as comets and meteoroids. On the cosmical scale the Solar System is local, and it is the only part of the universe which we can hope to explore physically, at least for the moment.

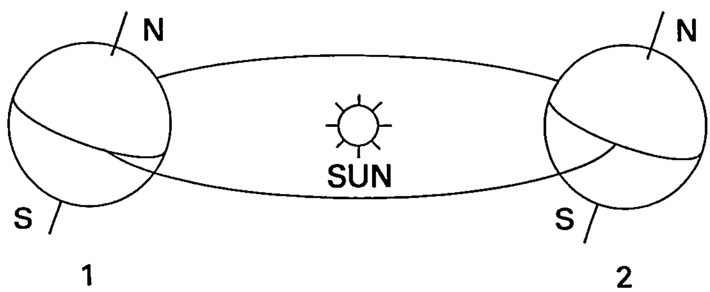
* A Metric–Imperial conversion table may be found on p. 206.

The Sun itself is a globe of gas, large enough to swallow up more than a million bodies the volume of the Earth, and fiercely hot even at its surface – which is why nobody should ever look directly at it through any kind of optical instrument, a point to which I will return later. It is not 'burning' in the conventional sense of the term, but is more in the nature of a huge, controlled atomic bomb, inasmuch as it is producing its energy by nuclear reactions taking place deep inside it. We depend entirely upon the Sun; without it the Earth and the other planets would never have been formed.

The ordinary stars are of the same kind, though of course they differ in detail. They are so far away that they appear simply as points of light, and no telescope will show them as disks. Also, they keep to virtually the same relative positions in the sky, so that the constellation patterns are the same now as they must have been in the time of George Washington, William the Conqueror or Julius Cæsar. The stars are not genuinely fixed in space, and are moving around in all sorts of directions at all sorts of speeds, but their remoteness slows down their apparent individual movements so much that the naked-eye observer will not notice them. If you compare the speed of a bird flying at tree-top height with that of a jet-aircraft high above you, the bird will seem to move quickly while the jet will crawl even though the jet is really much the faster of the two. The rule, is 'The further, the slower', and the stars are so distant that they seem to be fixed. Indeed, they were once commonly known as 'fixed stars' to distinguish them from the wandering stars, or planets.

We all know that the stars seem to travel across the sky from east to west, but this is due entirely to the fact that we live upon a spinning globe. The Earth rotates from west to east, and so the entire sky appears to revolve, carrying the Sun, Moon, stars and planets with it. The axis of rotation points northward to the north celestial pole, marked fairly closely by the brightish star known as Polaris; the south celestial pole is not near any bright star which southern-hemisphere sailors had cause to regret in the days when navigation was very much a hit-or-miss affair. And just as the Earth's equator divides the world into two hemispheres, so the celestial equator divides the sky into two halves.

Let us look at this situation a little more closely. The Earth's axis is tilted in its path or orbit by an angle of 23½ degrees to the perpendicular, which explains the seasons; when the North Pole is tilted toward the Sun (position 1 in the diagram) the northern hemisphere receives the full benefit of the solar radiation, while when the North Pole is tilted in the opposite direction



(position 2) it is the southern hemisphere which is favoured. Actually, the Earth's orbit is not quite circular; our distance from the Sun ranges from 147 000 000 kilometres in December out to 152 000 000 kilometres in June, but this is not enough to make much difference, and in any case the effect is compensated for by the fact that there is much more ocean in the southern hemisphere, tending to stabilize the temperature. Water heats up more slowly than land, but is better at retaining its warmth.

Go to the North Pole, and you will find that Polaris is overhead (or almost so; it is less than one degree of arc away from the polar point). The celestial equator will lie all round the horizon, and the stars will move in circles so that the stars north of the equator are always on view when the sky is dark enough, while those south of the equator can never be seen at all. As you move further south, Polaris will drop in altitude; from London, for example, it is only a little more than 50 degrees above the horizon, and some of the southern-hemisphere stars have come into view. From the equator, the two celestial poles lie on opposite horizons; from countries such as Australia, Polaris never rises and the south celestial pole never sets. From the South Pole the situation is exactly opposite to that at the North Pole, with the southern-hemisphere stars permanently visible except when they are blotted out by the brightness of the sky.

At an early stage, thousands of years ago, the stars were divided up into definite constellations. For instance, most Europeans can recognize the Great Bear, while Australians and South Africans are equally familiar with the Southern Cross. Yet the constellation patterns really mean nothing at all, because the stars are at very different distances from us, and the stars in any one particular constellation are not genuinely associated with each other; they merely happen to lie in much the same direction as seen from Earth. We happen to follow the constellation patterns drawn up by the Greeks, well before the time of Christ. If we had chosen, say, the Chinese or the Egyptian system, our star-map would look quite different – even though the stars themselves would be in exactly the same positions.

What about distances? With the stars, the mile or the kilometre is much too short a unit to be convenient, just as it would be clumsy to measure the distance between London and New York in millimetres. Luckily there is a better unit available. Light does not travel instantaneously; it flashes along at 300 000 kilometres per second, and in a year it covers 9.46 million million kilometres. This is the 'light-year', which, please note, is a measure of distance and not of time. It takes only about 8½ minutes for light to reach us from the Sun, but over four years from the nearest of the fixed stars. This also means that we see the universe not as it is now but as it used to be in the past. Deneb, a bright star in the constellation of the Swan, is about 1600 light-years away, so that we see it today as it used to be when the Romans were making ready to evacuate Britain.

The star-system of which our Sun is a member is known as the Galaxy. It contains about a hundred thousand million stars, and it is flattened; I have compared its shape, rather unromantically, with that of two fried eggs clapped together back to back. When we look along the main plane of the system we see many stars in almost the same line of sight, which explains the lovely band of the Milky Way. Appearances can be deceptive. The stars in the Milky Way, easily seen with binoculars, may look as though they are in danger of crashing into each other, but they are not genuinely crowded, and direct collisions must be very rare indeed.

Our Galaxy is not the only one. There are many millions of others, some of them much larger than ours. Three of these external systems are clearly visible with the naked eye (one in the northern hemisphere and two in the far south of the sky) and binoculars will show several more, though they are so remote that photographs taken with large telescopes are needed to bring out their details. By now we can range out to immense distances. Whether the universe is finite or infinite is something which we do not yet know, and it is not a problem which need concern us here, fascinating though it undoubtedly is.

Now let us come much nearer home and look at the Solar System, our own particular part of the universe. First there are the planets, of which nine are known. Mercury, Venus, the Earth and Mars make up the inner group; then comes a wide gap, in which move thousands of midget worlds known as asteroids, and then we come to the four giants, Jupiter, Saturn, Uranus and Neptune. The planetary system is completed by Pluto, a far-away, peculiar world which seems to be in a class of its own.

The planets move round the Sun at different distances in different times. Our own revolution period or 'year' is, of course, 365¼ days; that of Mercury is a mere 88 Earth-days, while Neptune takes over 164 years to complete one circuit. Most of their orbits are not very different from circles, though those of Mercury, Mars and Pluto are considerably more elliptical than that of the Earth. The planets have no light of their own, and shine because they are illuminated by the Sun. This tends to make us think that they are more important than they really are. Venus, Jupiter, and Mars at its best, are much more brilliant than any star, while Saturn and Mercury are bright enough to be noticeable; all these five were known in ancient times, though the three outer planets were discovered only in the telescopic era – Uranus in 1781, Neptune in 1846 and Pluto as recently as 1930. Only Pluto is too faint to be seen with binoculars.

Because the planets are so much closer than the stars, they move about against the starry background, though they keep within certain well-defined limits. This was how they were originally distinguished from the stars. The ancient Greeks worked out their movements with surprising accuracy, and were able to predict how they would behave.

All the planets except Mercury and Venus are attended by satellites. We have one natural satellite, our familiar Moon; Saturn has at least 18, though most of them are fairly small.

The Moon is our companion in space. It keeps together with us as we journey round the Sun, and moves at a mean distance of only 384 400 kilometres from us, so that anyone who flies ten times round the Earth will cover a distance as great as that between the Earth and the Moon. This, of course, is why the Moon dominates the night sky. It is a small world, with a diameter of only 3476 kilometres as against 12 756 kilometres for the Earth; represent the Earth by a tennis-ball, and the Moon will he about the size of a table-tennis ball, Its orbital period is just over 27 days, or a little less than a calendar month.

Because the Moon shines by reflected sunlight, only half of it can be lit at any one time, and the regular phases depend upon how much of the 'day' side is turned in our direction. When the Moon is almost between the Earth and the Sun, its dark or night side faces us, and the Moon is new, so that it cannot be seen at all. On the far side, the illuminated hemisphere is turned toward us, and the Moon is full. At other times we see a crescent, a half, or a three-quarter (gibbous) shape. When the Moon is near full it drowns all but the brighter stars, so that star-gazing is best done when the Moon is absent from the night sky.

Comets have been termed the stray members of the Solar System. They are not massive and substantial, as the planets are; a comet is made up of thin gas together with icy particles and what may be termed 'dust'. In most cases their paths are very elliptical, and since they too depend upon reflected sunlight we can see them only when they are in the inner part of the Solar System. The only bright comet which we see regularly is Halley's, named in honour of the astronomer who first worked out the way in which it moves. Halley's Comet returns every 76 years; it was bright in 1910, after which it moved back into the outer part of the system until its latest return in 1986. All other brilliant comets take so long to complete one circuit of the Sun that we never know when or where to expect them, and they are always apt to take us by surprise.

Though the twentieth century was rather comet-barren, there were two spectacular visitors in the closing years. The first was the comet of 1996, discovered by Japanese amateur Y. Hyakutake. It was a naked-eye object from March to May, and was probably the loveliest comet I have ever seen; it was delicate green in colour, with a long slender tail. It was also in the far north of the sky when at its best, and binoculars showed it magnificently. Unfortunately it was not bright for long – and it was in fact a small comet, but it came within about 10 000 000 miles of us, which by cometary standards was very close indeed.

It was outshone by its successor, Hale–Bopp, which could almost be classed as 'great', and which remained a naked-eye object for over a year. It was probably the most-observed comet in history. There was a gleaming head with spiral structure, and a dust-tail as well as a gas-tail; the dust-tail was beautifully curved. Between July 1996 and October 1997 it was on view, and binoculars were ideal for observing it and following its changes. The nucleus became as bright as Arcturus, and the comet was a familiar object in the evening sky. It was in fact a very large comet, but it never came within 120 000 000 miles of us; if it had been as close as Hyakutake, it would have cast shadows. Everyone was sorry to see it depart, and it was still a reasonably bright telescopic object at the start of 2000. It will be back in just over 2000 years – but Hyakutake will not return to perihelion for about 15 000 years. Whether the twenty-first century will provide any great comets remains to be seen; we can only hope.

There are many faint short-period comets, some of which can be seen with binoculars. Moreover, binocular-owners have often discovered comets which were not previously known.

If you see an object moving noticeably across the sky, it cannot be a comet, which is millions of miles away; you have to watch a comet for hours to notice any relative movement at all. A quickly-shifting object may well be one of the artificial satellites which have been launched in large numbers since October 1957, when the Russians opened the Space Age by launching their football-sized space-craft Sputnik 1. But if the movement is very rapid, and the object vanishes after a second or two, it will be a meteor. A meteor is a tiny particle, usually smaller than a pin's head, moving round the Sun; if it dashes into the upper part of the Earth's atmosphere, it rubs against the air-particles and is so heated by friction that it perishes in the streak of luminosity which we call a shooting-star. Meteors are common enough, particularly during the early part of August in each year, when our Earth ploughs through a swarm of meteors and collects a large number of shooting-stars.

I have had to cram this opening chapter with facts; I hope that you have not found it indigestible. Now, having cleared the air, so to speak, let us turn to our main theme – binoculars.

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Patrick Moore
Excerpt
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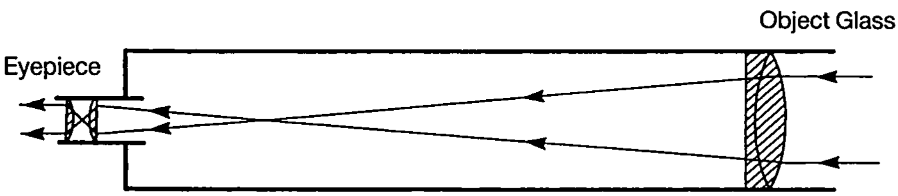
Binoculars of Many Kinds

It is seldom that a week passes by without my having several letters on the same theme. 'I have become interested in astronomy, so I want to buy a telescope. I can spend up to £50 ($75) or so. What sort of telescope should I get?'

Writing back is always something I find depressing, because the plain, unpalatable fact is that telescopes today are expensive items. It used to be possible to obtain second-hand telescopes at low cost, but by now a really good, cheap second-hand telescope is about as common as a great auk. In my view it is rather pointless to spend much money on any refracting telescope with an aperture of less than 3 inches (76 mm) or a reflector with a main mirror less than 6 inches (152 mm) in diameter. I emphasize 'in my view' because not everyone will agree, and of course a very small telescope is a great deal better than nothing at all. But given a choice between, say, a 60-mm telescope and a pair of good binoculars, I would unhesitatingly prefer the binoculars.

Telescopes are of two main kinds. With the refractor, the light from the object to be observed is collected by an object-glass; the light is brought to focus, and the image is then enlarged by a second lens termed the eyepiece. Note that the function of the object-glass is to collect the light, and all the actual magnification is done by the eyepiece. Changing the eyepiece means changing the magnification. In general, it is fair to say that one can use a magnification of × 50 for each inch of aperture (forgive my temporarily reverting to Imperial measure!), so that a 3-inch refractor will bear a magnification of × 150, a 6-inch will bear × 300, and so on. There are times when this limit can be exceeded, but it is a good enough rule. This is why I always distrust advertisements which offer, say, a 60-mm telescope '× 300'. For one thing, it is misleading to quote any definite power for a telescope, because it is the eyepiece which determines the magnification. Secondly, anyone who believes that a 60-mm refractor will bear a power of × 300 is going to be bitterly disappointed.



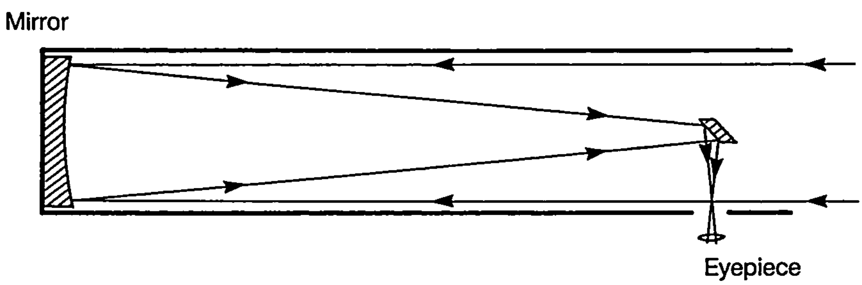
Light path in a refractor.

The answer is straightforward enough. Eyepieces are interchangeable (theoretically, at least), and so one can use any eyepiece with any telescope. In my observatory I have a 39-cm reflector, with which I can often use a power of × 600. If I used that particular eyepiece on my 76-mm refractor, I would still obtain a magnification of around × 600 – but the image would be so faint that it would be completely useless. The larger the telescope, the more light it can collect, and the higher the magnification which can be employed. Not that magnification is all-important; it is far better to have a smaller, well-defined image than a larger, blurred one even for observing the Moon or a planet.

The second type of telescope is the reflector. There are various optical systems, but the most common, at least in amateur hands, is the Newtonian, so named because the principle was first demonstrated by Isaac Newton more than three hundred years ago. Here, there is no object-glass. The light travels down an open tube until it hits a curved mirror at the bottom; the rays are then sent back up the tube on to a smaller, flat mirror placed at an angle of 45 degrees, so that the rays are directed into the side of the tube, where an image is formed and magnified by an eyepiece. With a Newtonian reflector, therefore, the observer looks into the tube rather than up it, so that for pointing to a planet or a star it is usually helpful to have a small refracting telescope mounted on to the side of the tube to act as a finder. (My 39-cm reflector has five finders, on the theory that the finder you want to use is always the one which you can't get at.)

Aperture for aperture, a refractor is more efficient than a reflector, and it is also easier to maintain. In fact it needs virtually no maintenance at all unless roughly treated, whereas the mirrors of a reflector have to be periodically re-coated with a thin layer of silver or aluminium. On the other hand a refractor is more costly, and in some ways less convenient to use.

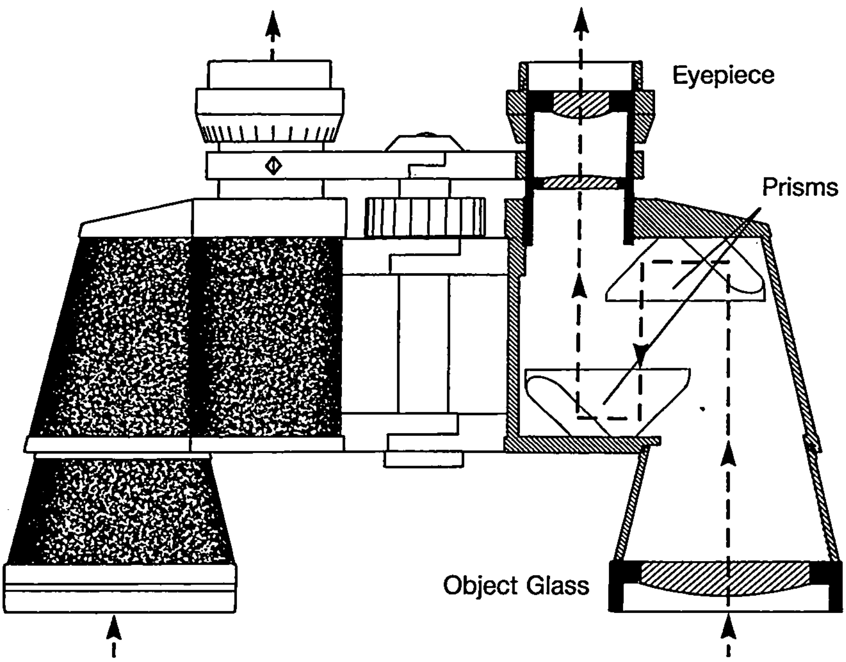
If you set out to buy a telescope, take great care. If the object-glass of a refractor or the mirror of a reflector is of poor quality, the images will also be poor – and a bad telescope does not always betray itself at a glance. Therefore, I recommend either giving the instrument a thorough test, or else asking for an opinion by an optical expert. Also, pay attention to the mounting. The essential need is firmness. If the telescope is mounted upon a spidery stand, it will quiver charmingly in the slightest breeze, and the image will dance about so violently that it will be useless.



Light path in a Newtonian reflector.

The cost of a 152-mm reflector is much the same as that of a 76-mm refractor. There are pros and cons, and everything really depends upon the main interests of the observer; for example, anyone who wants to make regular studies of the Sun will be far better off with a refractor, while the deep-sky enthusiast will in general prefer a reflector. But again I stress that light-grasp is all-important, and I am not at all happy about the very small telescopes which can be bought cheaply. They will not be satisfactory, though they will show some pretty sights. I would recommend them only for the casual observer who wants little apart from views of lunar craters. Note too that most astronomical telescopes give an upside-down or inverted image. In fact all ordinary telescopes would do so but for the addition of an extra lens-system to turn the image the right way up again. Each time a ray of light passes through a lens it is slightly weakened. This does not in the least matter when looking at birds or distant ships, but it is not helpful when observing a planet or a star, when it is important to collect as much light as possible. Therefore, the extra lenses are left out. If you want an 'all-purpose' telescope, you will have to buy a terrestrial converter into which the eyepiece can be fitted.

A pair of binoculars is nothing more than two small refractors joined together. The main advantage is that the observer can use both eyes instead of only one. The field of view will be much wider than that of a small astronomical telescope, and the binoculars are handier, so that they can be carried around very easily. A word of warning here. Every time you use binoculars, put the safety-cord around your neck. If you drop the binoculars, which is only too easy, there will be no harm done, but if you have forgotten to use the cord disaster may result. Dropping a pair of binoculars several feet on to hard ground is emphatically not to be recommended.



Light path in binoculars.