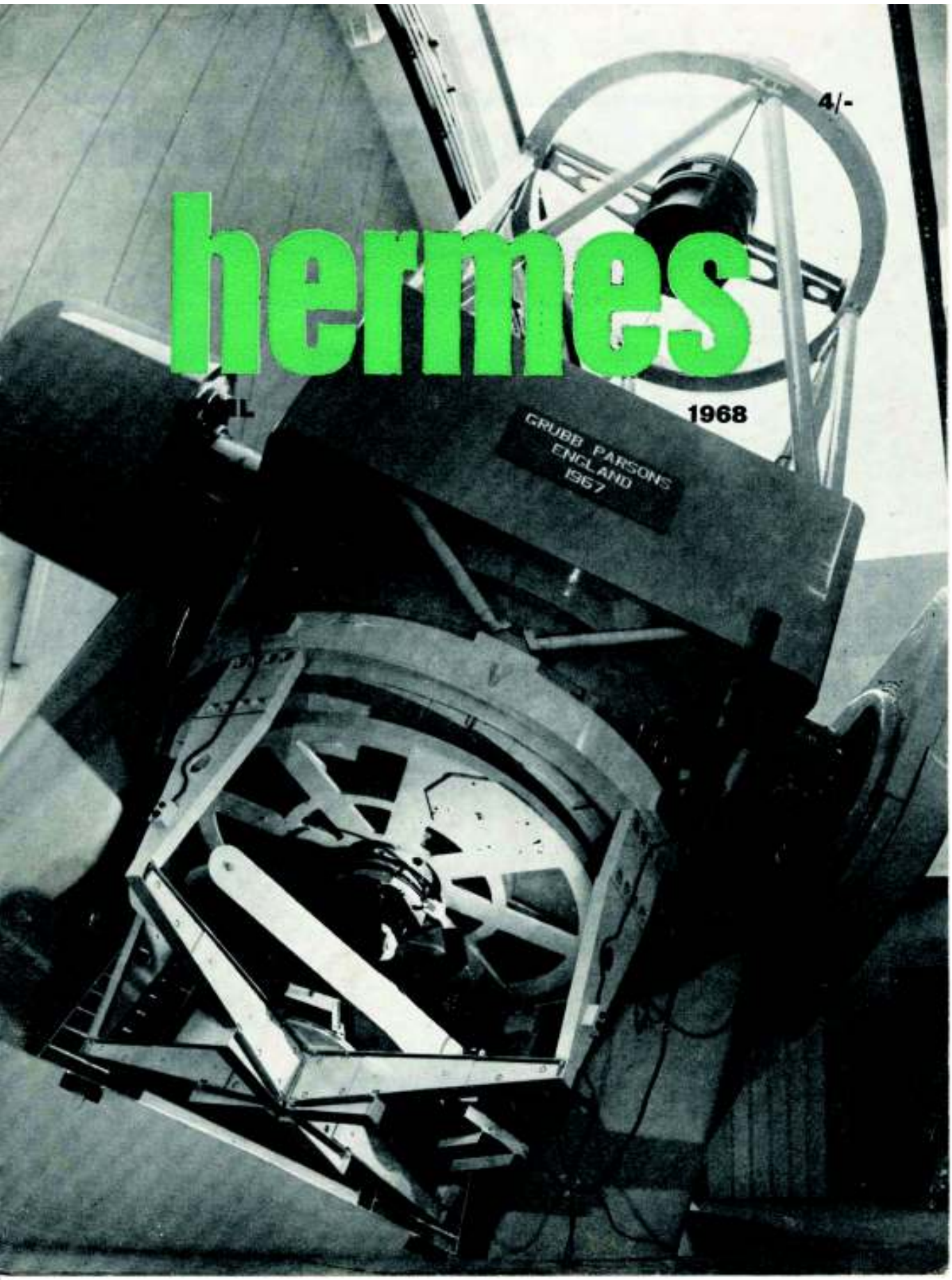

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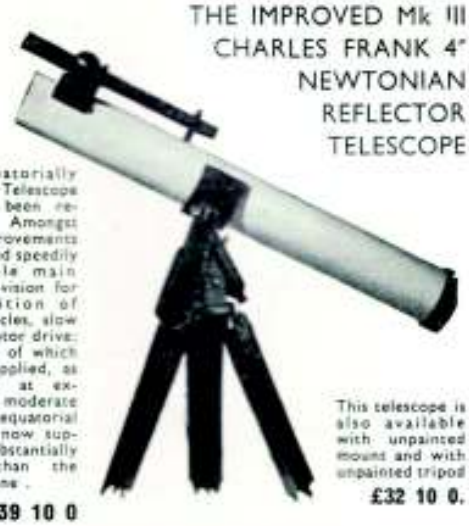

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COVER: Inside the dome of the 98-inch Isaac Newton Telescope, the fifth largest optical telescope in the world. The instrument, opened on December 1st, 1967, by the Queen, is housed in a 90-foot high building at the Royal Greenwich Observatory, Herstmonceux. Central Office of Information photograph. Crown copyright reserved.

comment

Prizewinner. In a close finish, first prize in the JAS literary competition went to Andrew Rowley of Bradford, Yorkshire, who stood out from his closest rivals largely because of better presentation. Miss Lydia Bevan of Isleworth, Middlesex, was a worthy runner-up. Commended entries were received from Tim Jackson, Daniel Ogilvie and Robert Webber. The winner will be receiving a splendid book prize, donated by Dr. Porter.

Changes. Through pressure of work, George Teideman, our former Editor, has been forced to leave his position of Public Relations Officer with the JAS, although he remains on Council. Mr. Teideman has put in much time and effort on behalf of the JAS over a period of many years, and we are most grateful to him; our Society would be a lot poorer without his presence. Peter Lancaster Brown is a new addition to Council. He has been an active astronomer for many years, and is internationally known. Mr. Lancaster Brown promises to have a long and valuable future in the "engine room" of the JAS.

Expansion. With the increasing scope of JAS Circulars, publication of the observing bulletin *Selen* is being ceased. The expanded Circulars are now printing observational material, and any outstanding money paid for *Selen* will be credited to an account with the Circulars. Observations should, of course, continue to be sent to the relevant Section Director in the usual manner.

Aeronomy. JAS satellite observations are valuable, and should be sent directly to the official receiving station, says S. W. Milbourn, Mr. Milbourn, Secretary of the BAA Satellite Section where all British amateur observations are reduced, gave tips on satellite observing at the last Caxton Hall meeting. Serious observers may contact Mr. Milbourn directly for satellite details. Remember—some basic equipment (and knowledge) is essential.

the radio galaxy

by Professor R. Hanbury Brown, FRS

Almost all our knowledge of things beyond our own Earth has come to us by radiation which can penetrate the Earth's atmosphere. It is true we have learned something from satellites and probes which travel outside the atmosphere, but nearly all the experiments carried out so far with these have been concerned with local things within our own solar system. In due course we can look forward to learning a lot more in this way, because satellites can receive radiation from a much wider range than we can on Earth. This, of course, is because the Earth's atmosphere absorbs so much useful radiation.

The most obvious sorts of radiation which penetrate the Earth's atmosphere are, of course, light and heat, but there are others less obvious, for example the fast particles called cosmic rays, which are studied by physicists. And then there are the radio waves used by radio-astronomers, with which I am concerned in this article. These are exactly the same sort of waves as light and heat, but they have a much longer wavelength—typically, radio-astronomers study waves of a length of about one foot, as opposed to the infinitesimal fraction of an inch that is the wavelength of light.

Blurred

This long wavelength has both advantages and disadvantages for the astronomer. One useful thing about the radio waves that pierce the atmosphere is that they will travel through clouds without being scattered in the way that light is—not only through the sorts of clouds we have in the atmosphere, but also through the great clouds of dust that lie out in space, cutting off the light from distant stars and preventing us from actually seeing most of our galaxy.

On the other hand a serious disadvantage of long waves is that they need correspondingly large instruments to focus them. Radio telescopes are large and expensive, and when all is said and done they give us only a very blurred picture of the sky.

Nevertheless, we accept our limitations, we scan the sky with our radio telescope and we compare our picture of it with the picture seen by our colleagues, the optical astronomers. First let us make this comparison in daylight. In the daytime we take it for granted that we cannot see the stars. In fact this is because the light from the Sun is scattered by the Earth's atmosphere to such an extent that the whole sky is bright, and against this bright background we can pick out only the Sun and perhaps the Moon. The radio-astronomer's view is different. The Sun is still bright to him but it no longer dominates the sky. The Earth's atmosphere does not scatter the longer radio waves in which he is interested and he can study objects well beyond the solar system by day as well as by night.

Flattened

If we wait till the night, then of course the optical astronomers come into their own. They see a host of stars; the brightest appearing in all directions because they are close, but the fainter ones concentrated into a band which we call the Milky Way. It is a side-on view of the flattened disc of stars that makes up the galaxy, as seen from our own position about two-thirds of the way out from the centre.

The radio-astronomer sees something quite different and rather surprising. He does not see the stars—except for the Sun, and he only sees that because it is so close.

The familiar constellations like the Plough and the Southern Cross have all gone. But their place is taken not by obscurity but by a wholly new picture. Now the radio telescopes reach through the dark clouds of dust and show us another aspect of our galaxy. There is a bright band of radio emission which follows the Milky Way across the sky; it is brightest when we are looking towards the centre of our galaxy. It is clear beyond any doubt that this bright band comes from the galaxy, but there is still a lot about it which we do not understand.

Mysterious

First of all, the radio waves which make up the bright band are not coming from the stars. Their origin is still partly mysterious, but in the last few years we have begun to understand it. There seem to be at least three ways in which these waves are generated. The first way—and incidentally the first one to be clearly understood—is by hot hydrogen gas in the space between the stars. This space is not, as one might imagine, a vacuum but instead is filled with a very, very thin gas, mostly hydrogen. Near a hot star the hydrogen atoms get broken up into oppositely charged parts—protons and electrons—and it is the rapid motion of the electrons which generates some of the radio waves which we see coming from the Milky Way.

But this hot hydrogen cannot explain the whole of the bright band of radio emission. There is some more powerful and unusual process also at work between the stars, and we now believe that this process is found in many radio sources throughout the universe.

This process is the "synchrotron" emission of radio waves by very high speed particles travelling through the space between the stars. These particles are electrons, which have the same high energies as the cosmic ray protons. The radio waves we pick up on Earth are generated when these electrons are deviated in a very weak magnetic field that must exist in the interstellar gas.

Finally we come to the third source of radio waves from our galaxy. This third source is exploded stars or, as astronomers call them, supernovae. A supernova is a massive star, which, reaching a critical condition in its interior, explodes and blows off its mass in an expanding cloud. The best-known supernova is the Crab Nebula which is the remains of a star which actually exploded in A.D. 1054.

We find that these expanding clouds are powerful radio sources and we see them by out radio telescope as bright patches against the continuous fainter background of the band that follows the Milky Way. Incidentally it seems possible that these remnants of supernovae may be the original sources of the fast particles which I mentioned earlier on.

I have dealt at some length with the origin of the radio waves from our galaxy because their origin is vital to our interpretation of what we see with our radio telescopes. We can make, and we have made, detailed radio maps of the sky and, as I have said, these maps show us the Milky Way very clearly indeed. So we do know we are looking at our own galaxy, but until we know more about the origin of our waves we have no proper key to our maps.

Immersed

Let me give just one clear example. Our radio maps show, much to our surprise, that the galaxy, which as you will remember is a large flat disc of stars, is immersed in a much larger region emitting radio waves. This may be a very extended corona or halo surrounding the galaxy, but nothing can be seen of it optically. We suspect that the disc of the galaxy is surrounded by a halo of very thin gas, but we cannot tell how it is formed, how it is supported or where it gets the energy which we detect as emitted radio waves.

So far I am afraid I have presented a rather nebulous picture of the radio galaxy,

but it is at least a picture which will tell us a lot when we understand it. Now let us look at a different and clearer picture which radio-astronomers have put together. Optical astronomers find that many galaxies show a pattern of spiral arms which stick out from a central nucleus. But they are not sure if this is true of our own galaxy. Radio-astronomers have been able to confirm that these arms do exist in our galaxy, and have been able to give use a clear picture of them. They have done this by studying the cold hydrogen gas which collects between the stars of the spiral arms.

Invisible

This cold hydrogen cannot be observed optically because it does not radiate light. But it does radiate on one particular radio wavelength, 21 centimetres. So if we, so to speak, tune our radio telescope to pick up 21-centimetre waves, we can detect clouds of this otherwise invisible hydrogen in the Milky Way. Next we want to find out where the hydrogen is and how much there is of it. We can get the direction of a particular cloud of hydrogen from the direction our radio telescope is pointing, and we can find out how much hydrogen is in the cloud from the strength of the radiation. We can also—and this is less obvious—get the distance of the cloud by measuring its speed.

I think I can best explain how we work out the distance of the clouds like this. Our galaxy, which is rather like a huge cartwheel, turns slowly all the time about its centre. But unlike a solid wheel, the time for one complete rotation round the centre is not the same for all parts of the wheel. The time depends on the distance from the centre. If you work this out in detail you find that because of this varying speed some parts of the galaxy seem to be approaching the Earth and some to be receding. Their speed relative to us depends on their distance. So by measuring the speed with which a particular cloud is approaching or receding, we can work out how far away from us it is.

Knowing the direction and distance of gas clouds, we can now go on to plot a map of cold hydrogen gas in the galaxy. In fact, this has been done and it is in my view the most important contribution which radio-astronomers have made to knowledge so far, for it gives the first reasonably complete picture of our own galaxy. We already knew, from optical work, that the galaxy is a thin disc of stars with a diameter of about seventy thousand light years and that the Sun lies in this disc at about twenty-five thousand light years out from the centre. We also suspected that this disc had a pattern of spiral arms. But now, since cold hydrogen gas happens to be concentrated into these spiral arms, when we look at the radio-astronomer's map of this gas we can really see for the first time—and it is a spectacular sight—the spiral structure of our galaxy.

We can now see that the disc of the galaxy is not smooth and featureless, but is made up of spiral arms. We can count these arms and we can see how thick they are, we can also follow them out from near the Sun into regions well beyond the galactic centre from which light could never reach us because of the clouds of interstellar dust.

In conclusion, we have seen that the radio-astronomer sees a different view of the galaxy to the optical astronomer. The optical astronomer is mainly concerned with the stars. The radio-astronomer is more concerned with what goes on in the space between the stars than he is with the stars themselves. It is in this space that we find the gas from which the stars are born, and so the investigation of this gas, made possible by radio-astronomy, helps us to understand how the stars seen by the optical astronomer came into being. In fact, at the moment the task of research—and a very inviting task—is to try to make one picture of the galaxy out of these two different views.

We wish to acknowledge the help of the author and Professor F. Graham Smith in the preparation of this article, which was adapted from the BBC publication *ABC of the Universe*.

new views about mercury

by Patrick Moore, FRAS

When we consider the amount of published material dealing with Venus and Mars, we tend to forget that Mercury—innermost of the planets—is also within what may be called 'probe range', even though it never comes much within fifty million miles of us. Of course, Mercury is a most unwelcoming sort of world, and it is not easy to observe; but it seems to merit more attention than it generally receives.

Mercury moves round the Sun at a mean distance of 36,000,000 miles, but its orbit is much more eccentric than the Earth's, so that there is a considerable difference between perihelion and aphelion distances. The diameter is usually given as 3,100 miles, but recent re-measures tend to reduce this to around 2,900 miles, so that Mercury is comparable with the Moon even though it is appreciably larger as well as being denser and more massive. The low escape velocity means that there is no appreciable atmosphere; traces of a mantle have been reported by Dollfus, Kozyrev and others, but there is no evidence firm enough to satisfy every critic. And until recently, it was assumed that the axial rotation period must be the same as the sidereal period or Mercurian "year": 88 Earth-days.

Mercury is difficult to study, because its nearness to the Sun means that it can never be seen against a dark sky except when hopelessly low down. Generally, all that can be seen is the characteristic phase, which, unlike that of Venus, does not seem to show a Schröter effect. (I went quite deeply into this some years ago; and though I am not yet entirely happy about the results, it does look as though the absence of Schröter effect is due to Mercury's lack of atmosphere.) Maps have been produced—but how reliable are they?

Schiaparelli produced a chart of the surface features. He was followed by E. M. Antoniadi, who, in the late 1920s and early 1930s, used the Meudon 33-inch refractor to produce what is still the officially-accepted map. The names of the surface features also are Antoniadi's; we have the Solitudo Hermae Trismegisti, Solitudo Criophori and others. Various later maps have been published, but it is not easy to take them seriously. Not so long ago, a map came out in a well-known American astronomical journal giving fine details on Mercury as seen with, I think, a 6-inch reflector. . . .

Certainly Antoniadi, a lynx-eyed observer, using a giant telescope, might have been expected to produce something reliable. And yet there are two disquieting facts. First, Antoniadi believed in the existence of an appreciable atmosphere, and said that on Mercury the atmospheric clouds were "more frequent and obscuring than those of Mars". I doubt whether any modern astronomer would credit this. Secondly, Antoniadi's map leads to the definite conclusion that the rotation period of the planet is captured: that is to say, 88 Earth-days. But if the recent American results are to be believed, the rotation period is only about 59 days; Mercury does not keep the same face to the Sun all the time, so that there is no zone of permanent day, no area of everlasting night, and no romantic Twilight Zone in between. This does not make Mercury any the less hostile, but it does seem to me to make nonsense of Antoniadi's map.

I have looked at Mercury on many occasions, sometimes using large telescopes. (By "large" I mean refractors over 18-inch aperture; with a reflector one is bound to run into trouble, since Mercury has to be studied in broad daylight.) I have seen some darkish

markings, but I have not been able to identify many of them. Frankly, I think that a new map is needed; this will mean a prolonged period of study with powerful equipment, and amateur-sized telescopes will not do. Neither will modest observatory telescopes; the Armagh 10-inch refractor, which is extremely good in quality, is not large enough, as I well know. Undoubtedly a better map will be produced sooner or later; meantime, we must admit that we know very little about the Mercurian surface.

Years ago—it must have been around 1949—I suggested that Mercury might have craters on it, similar to those of the Moon, and that the surface might well be lunar in type, though with a less regular arrangement of craters and probably less of a grid system. Since then, we have found that there are craters on Mars—though these I most certainly did not predict!—and I consider that there is every chance of their being present on Mercury too. Evidence for or against this idea will have to await results from a probe to the planet, and this will probably be done within the next few decades, if only to find out more about Mercury's mass. Meanwhile, look at Mercury when you have the chance; note its changing phase; try to make out the most prominent of its dark markings—but as yet, don't trust the published maps!

big numbers—a cosmological enigma

by Alan Wright, B.Sc.

If I were to measure two pieces of wood, I might find that one was 2 ft. long and the other 5 ft. long. If my rule was only able to read in inches I would find that they were 24 inches and 60 inches. Again, if I were to measure the same pieces with a metric rule I should find they were 61 cm and 152 cm. However, although that numbers have changed, nothing can alter the fact that one piece of wood is two and a half times as long as the other and that in each case the ratio of the two lengths, in whatever units they happen to be measured, is $2\frac{1}{2}$.

This ratio is an example of a Dimensionless Number. For another example let us look at the distance from the Earth to the Sun. This is about 93,000,000 miles or, more conveniently, $9{\cdot}3 \times 10^7$ miles. However, this number can be made as small or as large as we like by changing our yardstick. For example, this distance is $5{\cdot}9 \times 10^{12}$ inches, or $1{\cdot}5 \times 10^{13}$ cm, or 0·000015 light years. Similarly the ratio of any two measurements of the same quantity is also a Dimensionless Number, whether it be length, time, speed, weight or anything else, and so is not changed by changing our yardstick. Thus these ratios have a more fundamental significance than mere measurements expressed as so many feet, or pounds, or whatever.

Eddington, and later Dirac, were amongst the first to realise that there were amazing coincidences between the fundamental Dimensionless Numbers of the Universe. Events of everyday life are controlled by the behaviour of extremely small atomic particles. Eddington tried to find a connection between the world of atomic particles and the Universe as a whole. In this he was unsuccessful, but he did make one significant discovery—the Big Number ratios between the scale of the Universe and the scale of the atom.

The electron is the smallest of the basic building blocks of the Universe. If we try to estimate how many of these the Universe contains, we get the staggeringly large figure of 10^{78}. Now, taking the mass of the lightest atom, hydrogen, and comparing it with the best estimate for the mass of the Universe,

the greatest mass conceivable, we have approximately

Mass of Universe = 10^{54} grams.

Mass of hydrogen atom = 10^{-24} grams. The ratio is again 10^{78}.

To derive another Dimensionless Number we compare the two most fundamental forces acting between the electron and proton in the hydrogen atom. We find that the force of electromagnetism divided by the force of gravitation is approximately 10^{39}—which is the square root of 10^{78}. The smallest fundamental distance conceivable by atomic physics is the classical radius of the electron. Comparing this with the radius of the observable Universe we find again that their ratio comes out at something like 10^{39}. These four numbers are the only ones of fundamental significance that can be constructed.

The chances of these fundamental ratios arising by coincidence alone is so small as to be negligible. This encouraged Eddington in his suspicion that there could be some intimate connection between the atom and the Universe. In deriving these dimensionless Big Numbers, all numerical factors such as π, or 2, or 4π have been omitted. They could easily have been used to make the coincidences exact, but in view of the uncertainty of the basic data this is not very meaningful.

The final years of Eddington's life were spent following up this important clue. His work culminated in the writing of *Fundamental Theory*, published in 1946, in an attempt to mathematicize the very nature of existence. Unfortunately, Eddington's work is so involved and used such difficult arguments that only a handful of even the most brilliant scientists have found themselves able to examine this work in detail.

Serious doubts have been entertained as to the cosmological significance and usefulness of Eddington's work. Nevertheless the relations remain as tantalizing pointers to a fundamental relation between the atom and the Universe.

books by Susan Fiennes

ABC of Astronomy by A. Weigert and H. Zimmermann. Adam Hilger Ltd., 1967. 368 pp. + 20 plates. 50/-.

ABC DER ASTRONOMIE was first published in Eastern Germany in 1960, the work of two authors from the University of Jena, and justly won for itself a reputation as the most extensive and professional publication of its type. This English edition is a conscientious and able translation of the 1967 second edition, and remains far in advance of any competitors.

The publishers do not advertise it as a glossy, luxury production. The type is tiny and the pages appear cramped; the diagrams are rather small, and many of the photographs show evidence of having been re-screened from other publications. The book is also characterised by a peculiar smell, presumably a result of the inking on this German litho production.

But in content there is very little to criticize. The full spectrum of astronomy is covered in a well-balanced fashion, the most important subjects being singled out for article-length reviews. A particularly useful habit of the authors is the inclusion of thumbnail biographies on famous astronomers; at last I can sort out the various members of the ubiquitous Struve family. The pull-out maps and pocket planisphere hardly replace Norton's, but are at least a useful guide to the constellations and their boundaries.

ABC of Astronomy contains about 1,200 entries and over a quarter of a million words. In a work of this kind, it is easy to find missed entries. Drs. Weigert and Zimmermann are remarkably complete in their coverage, providing copious cross-references.

This is not a beginner's book; but it makes an excellent companion to the other volume reviewed here.

Essentials of Astronomy by Lloyd Motz and Anneta Duveen. Blackie & Son, 1966. 711 pp. 70/-.

THE COMPLETE book on astronomy can never be written. Nevertheless, many comprehensive texts have been attempted, the best being those written for first-year astronomy students. This four-part volume, by two teachers at Columbia University, is not only the best example of its class, but also the most outstanding general astronomy text ever produced.

The framework is similar to Struve's *Elementary Astronomy*, but the treatment is far more comprehensive and detailed than even that classic work; Motz and Duveen have produced what is virtually an astronomical encyclopaedia. This is not a book for the very young. Simple equations and formulae are stated where necessary, but the mathematical treatment is deliberately and successfully kept to a level understandable by those who have a background in algebra only.

Essentials of Astronomy is beautifully printed and lavishly illustrated. Throughout, there are hundreds of excellent photographs and clear, simple diagrams, the majority of which are most effectively double-colour printed. The Index is most impressive—it runs to 20 pages. This English edition is a direct reprint from the existing American plates, and consequently there is no amendment of spelling or slight errors—such as in a diagram captioned "The viewing of comets" which actually refers to meteors.

Nevertheless, the text is authoritative on every branch of astronomy, all the way from the solar system to stars, galaxies and quasars. In relation to its presentation and content, the price of the book is remarkably low; in fact, it renders absolutely every other introductory astronomy text superfluous. Already, *Essentials of Astronomy* is becoming the standard work for "O" level astronomy studies, and must doubtless also become the favourite stepping stone for the amateur who wishes to improve his view of the universe.

spectrum

by Joslyn Darby

Patron honoured by Royal Astronomical Society

JOHN GUY PORTER, Patron of the Junior Astronomical Society and for twenty years a Director of the British Astronomical Association's Computing Section, was, on February 9, 1968, awarded the Jackson-Gwilt Medal and Gift of the Royal Astronomical Society. The award was made in recognition of his work on the orbits of comets and meteors and of his activities in the promotion of public interest in astronomy.

Dr. Porter was a professional astronomer in H.M. Nautical Almanac Office from 1949 until he retired in 1961. Although he took his first degree in chemistry, which he then taught, he obtained his doctorate for a penetrating analysis of the observations of the orbits of meteors, thereby establishing himself as an authority in the field.

In presenting the award, Mr. D. H. Sadler, RAS President, said: "Porter's greatest service to our science may well prove to be the encouragement of informed public interest in astronomy. His monthly radio talks, *The Night Sky*, from 1946 to 1961 set a pattern for the combination of authoritative information with absorbing interest; he has the great gift, or more probably the acquired characteristic, of being able to communicate his own enthusiasm and he has used this to the full. He has since contributed to many other radio and television programmes dealing with astronomy, including schools broadcasts, and he has lectured widely. He must have been responsible for encouraging thousands to look at the night sky with increased understanding, and with greater respect for the achievements of astronomy."

The friendly opticians

ASTRONOMICAL EQUIPMENT (Luton) Ltd. are a very friendly optical works. "Come and look round," they said. So I went.

Their shop is a blue-fronted oasis in a fence-like line of half-forgotten buildings near Luton station. Inside, the skeletons of telescopes hang from the walls. But the four working Directors of AE are industriously putting life into their plans for quality optics at economy prices.

"We aim to make and test everything under one roof," said Director Jim Hysom, 34. "That way we market things cheaper than anybody—even the Japanese." The success of AE's cost-cutting measures is reflected in their export market, which is increasing rapidly. Many moderate-sized telescopes are being sold all over the world, especially to America where there is a vast market in educational astronomy.

Dr. Porter displays the Jackson-Gwilt Medal after the presentation.

High-speed grinding and polishing machines can produce a finished mirror or lens in a fraction of the time it would take to handgrind. Two and a half thousand r.p.m. rotating diamond tools automatically rough out the glass blanks to shape; fine-grinding is done by hand, with carborundum, over a rotating cast-iron tool. And in the background polishing machines groan away the last agonising hours to an optically perfect surface.

"Anything not perfect is re-worked," say the Director of AE. "It's a waste of time, but we do it. We aim for better than $\frac{1}{10}$th wave accuracy —that's a millionth of an inch. This makes sure all the light goes into the image where it's needed. It keeps star images small and increases contrast. We don't allow scratched surfaces to go out at all; we set ourselves a much higher standard than anyone else at the same price."

Right: AE Director John Mathers with a 10-inch tube and special-design equatorial head.

Unveiling two of the secret scientists of Britain . . .

"LET ME tell you about my discoveries." T. B. Orton lives within a kangaroo's hop of the Earls Court Road and is rather reticent about his age. He owns several unlikely-looking pieces of apparatus, his pride being the self-anointed "Ortoscope". He was willing to let us be the first to know what it would do.

The first surprise was its determination of stellar compositions—from photographs. He claims to have used this method on Nova Delphini pictures: "The Royal Greenwich Observatory spectrogram of the nova shows calcium—but that's from the Earth's atmosphere. That's where I've beaten them." He also seemed to think that Harold Spencer Jones was Astronomer Royal. We pressed on.

For according to him, everything starts out as hydrogen and then progresses up the atomic scale, passing through a cometary phase and then becoming a planet. Measured from our photographs, the Andromeda galaxy was of atomic weight 130, he told us. "It will soon start to career round like a comet. Of course, it could take two or three light years."

A WEIRD contrivance, which worked without any operator interference, was demonstrated to the N.E. and E. London Group of the JAS (now NELAS) in October, 1956.

The fact was, a certain Mr. X, being extremely interested in cosmic rays, assembled a piece of apparatus consisting of wire, some rods—"shields from magnetic fields"—and a sharpened copper bar. An electric bell was mounted on a separate piece of wood together with a torch bulb and motor.

Mr. X then explained that cosmic rays fell on the sharpened copper bar, and electricity was produced which ran to the bell, lamp and motor. The apparatus was demonstrated, and the bell was duly rung and the lamp lit. Mr. X explained that a much larger device would be powerful enough to drive a car.

The apparatus was carefully examined and nothing seemed to indicate that the machine was a hoax. About a year after, Mr. X entered a mental hospital; consequently negligible information has since been obtained. Today no one is any the wiser and this remains a mystery.

are peculiar galaxies peculiar?

by Paul G. Murdin B.A. (University of Rochester, New York)

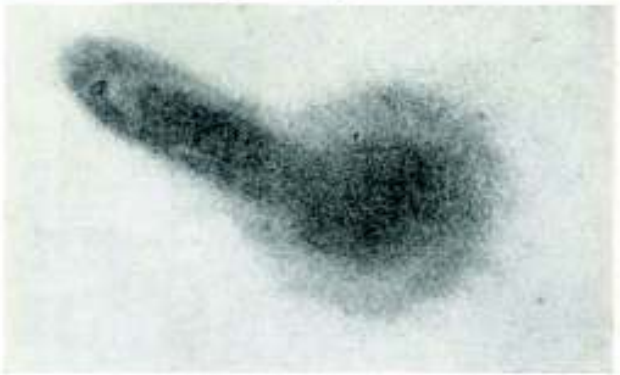
A prerequisite for the study of a subject is a mapping out of all the objects to be explained. This point of view has been emphasized by Fritz Zwicky with his researches with the 48-inch Schmidt telescope. He set himself the conscious task of discovering all the kinds of objects in the Universe he could think of—and in startling measure has succeeded. His discovery of faint blue stars and the dwarf galaxies in abundance is vindication of his basic empirical viewpoint.

One of the direct outcomes of the Zwicky viewpoint (which is described in his book *Morphological Astronomy*) was the *Palomar Sky Atlas*, consisting of reproductions of 48-inch Schmidt plates taken for the entire sky visible from Mt. Palomar. Everyone is impressed just looking at the charts, with the abundance of galaxies registered on the plates. One astronomer who systematically searched the *Palomar Atlas* inspecting the images of galaxies was the Russian B. A. Vorontsov-Velyaminov. He published in 1959 a selection from the *Palomar Atlas* of blow-ups of interacting galaxies. One of the galaxies illustrated was the celebrated Whirlpool Galaxy (M 51) with an elliptical galaxy (NGC 5195) stuck at the end of one spiral arm of the larger spiral galaxy (see *Hermes*, October 1967).

Apart from interacting galaxies with bridges between them, Vorontsov-Velyaminov found lone galaxies with bridges jetting into—nothing! These galaxies were labelled *peculiar* and gradually every galaxy that could not be fitted into the Hubble scheme found itself with that label, including the interacting galaxies. The 48-inch Schmidt had revealed the extent of this class of galaxies—precisely its morphological intention.

Now a new Atlas has appeared. The *Atlas of Peculiar Galaxies* by Halton Arp consists of reproductions of photographs taken with the 200-inch Palomar reflector. It is published in two forms—as a bound volume of direct photographic reproductions and as *Astrophysical Journal Supplement* No. 123, November 1966.

Here are 338 *peculiar* galaxies of all kinds—galaxies with jets, with rings, with countertails; spirals connected to ellipticals; spirals of low surface brightness; spirals with one extra bright arm; double galaxies, groups of galaxies, chains of galaxies. One feels, leafing through the *Atlas*, that if one can imagine a peculiarity involving a galaxy then it is illustrated somewhere here. It goes without saying that no one knows how to explain these objects.



"Spirals appear disturbed," says Arp tersely of NGC 5544+45, the official name for this long-known object.

The following is, I feel, a significant point. We should not prejudice our opinions of these objects in any way before we can satisfactorily explain them. Hence the name *peculiar* for these galaxies is objectionable.

Take another instance in recent astronomy where the term peculiar is badly applied, as is just now becoming apparent: the "*peculiar stars*". What this term really means is "stars which do not fit in to the Morgan-Keenan classification". It has been applied (amongst others) to metallic-line A-stars, P Cygni stars, Wolf-Rayet stars, cyanogen

A ring without a centre, and a filled ellipse—a peculiar galaxy with perhaps some distant relationship to barred spirals.

The querying loop (LOWER RIGHT) *has been identified with a radio source.*

stars and stars known even now as peculiar A-stars. As we study these objects, however, we begin to realize that they are perfectly explainable (although they might not yet have been explained). For example, Abt has shown that metallic-line A-stars are all members of binary systems: presumably this is connected with their peculiarity; or, put another way, binariness "causes" metallicity—any A-star in a binary would be a metallic-line star. They are no longer peculiar—just binaries.

We get another justification for this viewpoint that *peculiar* galaxies are not peculiar from the *Atlas* itself.

One of the peculiar objects is a galaxy consisting of a ring without a centre and a sausage-shaped object a little way away (*see photograph*). What could be more peculiar? Yet we see in the *Atlas* no less than three representatives of this peculiarity with the sausage positioned nearby to, and in the centre of, the ring—as if in some way they are examples of different degrees of evolution of the ring and sausage. Indeed if we call the "sausage" a bar and the "ring" a spiral, we are forced to recognize the similarity of this *peculiar* galaxy to—barred spirals!

Naturally, this doesn't explain anything, but it is a point of view which we cannot rule out.

One more thought: Arp has found that a significant number of quasars occur in pairs of equal brightness with a *peculiar* galaxy halfway between them. Can it be that this is the "explanation" of *peculiar* galaxies, in the same way that peculiar metallic-line A-stars are "explained" by binariness? Clearly it is too soon to tell. Let us not prejudice this explanation by a bad nomenclature.

I will leave the final question to the *peculiar* galaxies themselves:

observing the constellations

by Peter Lancaster Brown, FRAS

The constellation Ophiuchus (pronounced of-i-ukus) or Serpent Bearer, lies exactly in mid-heavens being situated half-way between the North and South poles and also the Vernal and Autumnal Equinox. Although the ecliptic passes within its southern borders, it is not included among the traditional zodiacal groups. On the older maps the constellation was intermixed with Serpens. The ancient astronomers who named them imagined they saw the figure of a giant grasping a writhing serpent with his hands, and thus the title Ophiuchus is derived from two Greek words meaning: "The man who holds the serpent." His head is supposed to lie just below the Northern Crown.

The configuration, although large in area, is not a prominent constellation to the casual eye, but it is rich in telescopic objects. Perhaps it is best observed in the British Isles on a clear, moonless summer night. It is advisable to have a guide chart, and one can locate it by extending a line between the prominent Northern Crown and the star Altair **(Alpha Aquilae).** Almost exactly halfway is the brightest star of the constellation, Alpha magnitude 2·1, a white star popularly known by its Arabian name Ras alhague—The Head of the Serpent-Charmer.

Beta Ophiuchi (Cebalrai)—"the heart of the Shepherd"—is nine degrees to the south-east of Alpha and is a yellow-orange colour, magnitude 2·9.

Delta Ophiuchi (Yad)—"in the hand"—is another yellow-orange coloured star, magnitude 3·0, and is just within the modern boundaries of the constellation.

Lambda Ophiuchi is a binary system, magnitudes 4·20 and 5·25, and with a period of revolution of 132 years. Separation is 1·1 secs. of arc and although the distance is increasing, it requires at least a 6" O.G. to be sure of splitting them.

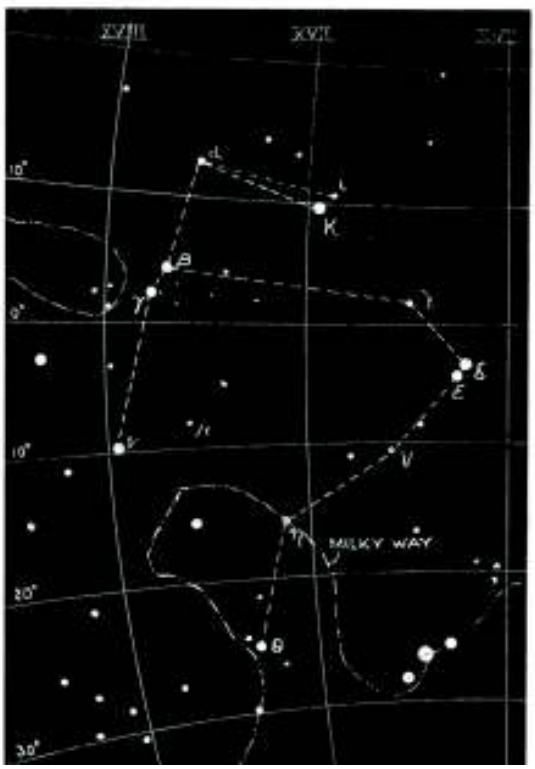
Rho Ophiuchi is another beautiful binary system, magnitudes 5·7 and 6·4. This star will easily be located if the night is transparent as it is only 3° north of the bright star Antares which, on a summer's evening, from the British Isles, can be seen flashing iridescently just above the southern horizon.

Tau Ophiuchi is a binary system with a period of 223 years, magnitudes 5·3 and 6·0,

angular separation 1·9 secs. and just within range of a top class 3" O.G. and a moderately high power.

Two other binary pairs well within range of the smaller refractors are **70 Ophiuchi,** magnitudes 4·3 and 6·0, separation 3·4 secs, period 88 years, and **36 Ophiuchi,** magnitudes 5·3 and 5·3, separation approximately 4·0 secs, period 549 years.

One of the most interesting stars in the constellation is one first noticed in 1916 by the famous American Professor E. E. Barnard, who found after checking back through older photographs that the star had a very large proper motion mounting to just over 10 seconds of arc. Visually it is a faint star, of magnitude 9·7, but trigonometrical parallax measures show it to be a new neighbour of the sun only 6 light years away. This being so implies that Barnard's Star is a dwarf variety very similar to Kruger 60 (see *Hermes*, p. 148, October, 1967). Although both its mass and radius are only ⅕ that of the Sun, its density is at least twenty-five times greater! Its rapid motion can be appreciated better if one considers that in 175 years its apparent motion is equal to the angular diameter subtended by the full Moon.



Ophiuchus is also a rich region for variable stars and additionally, because of the proximity of the Milky Way, numerous novae have been discovered within its borders. One of the most peculiar of all—**RS Ophiuchi**—is what is called a recurrent nova and first came to notice with an outburst in 1898, after which it rapidly faded back to magnitude 10. It brightened again in 1933, 1958 and recently on October 26th, 1967, a rise which was co-discovered by Douglas Saw, a British amateur living at Aylesbury, Buckinghamshire. This is a star which must be included in the list of every observer for one day he may have the good fortune to make an independent discovery of a future flare-up.

Before 1850, four bright novae were known to have occurred in Ophiuchus. The first was seen in 123 A.D., the second in 1230 A.D., the third one in 1604, and it is popularly known as "Kepler's Star". The latter star, however, was probably discovered by his pupils Mostlin or Brunowski, but Kepler wrote a book about it. This was no ordinary nova, but a type known as a supernova of which only three are known to have occurred within our own galaxy. It became as bright as Jupiter, but then gradually faded away to complete obscurity. Its location is near Xi Ophiuchi and no stellar survivor has been observed in its place. However, a nebulous remnant has been photographed which is heavily obscured and greatly reddened, and is about 4 magnitudes fainter than the Crab Nebula Supernova remnant of 1054 A.D. In 1955, a radio source was positively identified as originating from this nebulous remnant.

Another famous nova was discovered in 1848, by the celebrated British Astronomer J. R. Hind from Mr. Bishop's observatory in London's Regents Park. These days one could hardly imagine discovering a new 4th magnitude star from such an unlikely smog-laden location! Hind's star is still visible and is considered to be slightly variable over a magnitude range 12·2 to 13·0.

society notices

Life Membership of the JAS has been conferred on Miss Rossie Atwell in recognition of her unflagging efforts on behalf of the Society over a great number of years. It is with great pleasure that we record the warm appreciation expressed to her at the SGM in January.

Keele day trippers are most welcome at the JAS Fifteenth Anniversary meeting on March 30-31. Those who have not booked meals in advance may bring a sandwich lunch; arrival is at the Physics Department between 11 and 12.30 on Saturday, 10-10.30 on Sunday. Entrance fees (covering film shows, lectures and observing) are 10s. for Saturday, 7s. 6d. for Sunday. Details on page 24 of the January *Hermes*.

Sky and Telescope raises its prices on July 1st this year. JAS will still keep the very lowest rates anywhere for this authoritative American monthly—but beat the rise by taking out a three-year subscription NOW! Send £8 2s. (non-members £9 3s. 6d.) for thirty-six issues to Mrs. V. Longman , 65 Speer Road, Thames Ditton, Surrey.

BAA Handbooks may be purchased by JAS members at the reduced rate of 7s. 6d. per copy. Members wishing to buy a copy should write to Miss L. Brown, Assistant Secretary of the BAA, 303 Bath Road, Hounslow West, Middlesex, enclosing a cheque or PO made payable to the British Astronomical Association and quoting their JAS membership number.

The Sound of Astronomy is preparing a new tape; catch up on existing tape lectures by contacting Miss Janet Beglan at 17 Chanctonbury Chase, Redhill, Surrey.

Remember that s.a.e. JAS Officers are unpaid and don't claim expenses. Next time you write to one, enclose an s.a.e.—it creates a much better impression!

REPORT ON SGM OF 1968, JANUARY 27. The proposed changes to Rules 5(2) and 7(2) were carried nem. con. The meeting was in favour of the affiliation Rule but felt that an amendment put up at the meeting was preferable as it made the relationship to the other Rules explicit. Council reconstituted the Rules sub-committee with the Chairman and Secretary of the Croydon Astronomical Society (originators of the original idea) as members. Their recommendation is to retain the wording as printed in *Hermes* in January with the words in italics added: 3(3)—AFFILIATION OF SOCIETIES AND GROUPS. Societies and Groups may apply for affiliation to the Junior Astronomical Society. *Subject to the Council's approval of the application*, affiliation would be effective by payment of one *annual* subscription per affiliated body. This would entitle the affiliated body to the privileges enjoyed by an individual member of the Junior Astronomical Society *under these Rules*:

The effect of these additions is to invoke the following Rule 4 which gives Council power to refuse an application from "undesirable" Societies and grants the affiliated body one vote only on Society matters (non-JAS members of the affiliated body would not have the right to vote). Whilst on this question of votes, it should be noted that the effect of passing the new Rule 7(2) is to change the number of votes in 7(4 and 6) from 3 to 8.

This amended wording will be put to the General meeting on 27th April, for confirmation. The full programme of the April meeting is:—

14.00—14.30 Beginners' Session—"The JAS Observing Sections".

14.45—15.45 "Observing the Sun", Mr. W. M. Baxter, FRAS, Director of the BAA Solar Section.

15.55—16.55 "Lasers", Mr. W. T. Gunston, Technology Editor of *Science Journal*.

16.55—17.00 Confirmation of above Rule.

sky diary

by Norman Wright, FRAS

Principal Phases of the Moon **All Times GMT**

	APRIL	MAY	JUNE	JULY
Full	13d 04h 52m	12d 13h 05m	10d 20h 13m	10d 03h 18m
New	27d 15h 21m	27d 07h 30m	25d 22h 25m	25d 11h 49m

THE TIME at which Full Moon occurs on April 13 is significant, as this is also the middle of the period of totality of the Lunar Eclipse on that date. Conditions are by no means favourable for observation in Britain—the Moon is low in the S.W. sky even when totality begins—but such is the relative rarity of the chance to see a total eclipse, allied to the fact that this one occurs in the Easter holiday period, it is worth missing some sleep for a peep! Any careful timings of occultations which may occur while the limb of the Moon is darkened by the shadow of Earth will be gratefully received, though a low horizon to the S.W. and a larger-than-average telescope will be necessary. Umbral eclipse begins 03h 10m—totality from 04h 23m to Moonset.

Lunar Occultations (Greenwich Predictions)

Date	Star	Mag.	Phase	Time	Position Angle (degs.)
April 6	Omega Cnc	5·9	D	23h 45·4m	52
6	4 Cnc	6·2	D	24h 03·6m	111
8	+21 1952	7·5	D	01h 46·4m	157
May 2	+21 1219	6·8	D	21h 40·9m	71
3	76 Gem	5·4	D	23h 31·0m	104
31	Lambda Cnc	5·9	D	22h 08·7m	35
	(Grazing conditions at Edinburgh)				
June 6	−9 3669	7·0	D	23h 02·4m	105

THE STAR Lambda Cancri grazes past the N. limb of the Moon as seen from Edinburgh on May 31, and predictions would be very approximate, if issued. Those observing in the North of England and in Scotland can do valuable and interesting work at this time by watching the behaviour of the star for some ten minutes before until ten minutes after the predicted occultation time at Greenwich. Comments and any timings will be welcomed by the writer. If an observer is very close to the occultation limit, it is possible to see more than one occultation as the star passes behind irregularities at the limb of the Moon.

Lyrid Meteors. Moonlight not interfere with observation of this meteor shower in 1968, and the limits of activity are expected to be April 19-23, with a maximum in the early hours of April 22. Remember that the radiant does not reach a reasonable altitude until about midnight, and the most rewarding time to observe is from then to around 3 a.m.

MERCURY passes Superior Conjunction on April 24 (beyond the Sun from Earth) and then moves into the evening sky. From about May 9 until the end of the month this planet will be well placed for observation in Britain, setting as much as 2¼ hours after the Sun around May 20. Binoculars with a wide field of view are probably about the best instrument for finding this object, the appearance being rather like that of a bright star becoming visible as the twilight fades. In all telescopes of a size such as used by amateurs, Mercury is a disappointing sight, and it is usually a sufficient achievement to locate the planet with the eye or binoculars. This year it may still be found in early June with difficulty, as it moves toward Inferior Conjunction (between Earth and Sun) which is on June 18.

VENUS lies only 15 degs. West of the Sun in mid-April, and is moving steadily toward Superior Conjunction, occurring on June 20. This planet remains badly placed not only during this period, but until almost the end of 1968.

MARS is similarly "out of the running" for most of 1968. It is in Conjunction with the Sun on June 21, and will be unobservable from April to September, especially in view of its faintness when at this great distance from Earth.

JUPITER is stationary on the star background on April 22, about 3 degrees West of Regulus, and on that date is high in the South at 19h 51m. It is therefore ideally placed for evening observation, and will remain so for many weeks. There are two occasions in April when rare mutual phenomena of the satellites of Jupiter can be observed from Britain. At both times the planet will be rather low in the S.W. sky. On April 7, there is a partial eclipse of Satellite III (Ganymede) by Satellite II (Europa) starting at 01h 38m and finishing at 02h 08m. The drop of 25% in the light from Ganymede should be apparent at around 01h 53m, and in large telescopes the actual shadow on the disk of the satellite will be visible. On April 28 Satellite III (Ganymede) is occulted by Satellite II (Europa) starting at 0h 18m and finishing at 01h 04m. In this case, in all telescopes except those of large aperture, the satellites will appear to merge into one bright object. Even at the end of June, Jupiter does not set until 23h, so some evening observation is still possible.

SATURN is at Conjunction with the Sun on April 5, and not until about mid-June will it be possible to see the planet with any ease in the East shortly before sunrise, situated in the S.E. corner of the constellation of Pisces.

Small Ad.

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