Occasional Notes

No. 3 An Independent Miscellany of Astronomy 4 February 2019

In 1672, when Isaac Newton read of the enigmatic Monsieur Cassegrain's design for a reflecting telescope, he expressed his opinions in a letter to Henry Oldenburg, Secretary of the Royal Society. After extensive adverse criticism, the letter concludes: 'You see therefore, that the advantages of this design are none, but the disadvantages so great and unavoidable, that I fear it will never be put in practise with good effect ... I could wish therefore, Mr Cassegrain had tryed his design before he divulged it. But if, for further satisfaction he please hereafter to try it, I believe the success will inform him, that such projects are of little moment till they be put in practise.' Subsequently, the Gregorian design was predominant throughout the eighteenth century, while Newtonian telescopes became very popular with the introduction of silver-on-glass mirrors in the late 1850s. If Newton could be informed that the Cassegrainian design is now incorporated in many instruments, it is probable that he would respond in a characteristic manner with an acerbic comment.

Bob Marriott

John Hadley's reflecting telescope

After the efforts of Gregory, Reive, Newton, Cox, Hooke, and Cassegrain from the mid-1660s until around 1704, development of the reflecting telescope remained quiescent until 1719/20, when John Hadley produced a fully workable Newtonian instrument which he afterwards presented to the Royal Society. It was tested by Edmond Halley, and was so successful that another was ordered to be built. Hadley's account of his telescope, with some observations, was published in *Philosophical Transactions* in 1722. The illustration accompanying this paper (see next page) has been reproduced many times, often in inferior quality, but except for Hadley's paper I have never encountered a detailed description of the design and workings of the instrument, which are far more refined than would at first appear. The description presented here is in part distilled from the linguistic convolutions of three centuries past, without the need to refer to the key letters. Hadley did not provide any information on the composition of the metal, nor whether he cast and worked the specula himself, but he was assisted by his brothers George and Henry, and it is possible that some of the components were produced by anonymous carpenters and metalworkers.

The primary speculum was half an inch thick and about 6 inches in diameter, with a focal length of 62⅝ inches (about f/10.2). It was held in place in the tube with three small brackets placed equidistantly and above it, and three adjustable screws below it, preventing movement but without exerting pressure on it. The back of the speculum was provided with a hole into which a handle could be screwed. This handle moved through a slot extending from the centre of the base of the telescope to its open end at the perimeter, and a hinged door was incorporated in the side of the tube so that the speculum could easily be installed and removed by sliding it sideways with the attached handle, thereby avoiding contact with the polished surface. This was convenient and essential, as the metal tarnished very quickly, and it was necessary to keep specula in dry storage when not in use. The speculum could also be stopped down with circles of pasteboard to reduce the aperture by different amounts – a technique which in later times was often used for improving the image produced by a mirror with an inferior figure in the outer zones, though with loss of light and a reduction in resolution.

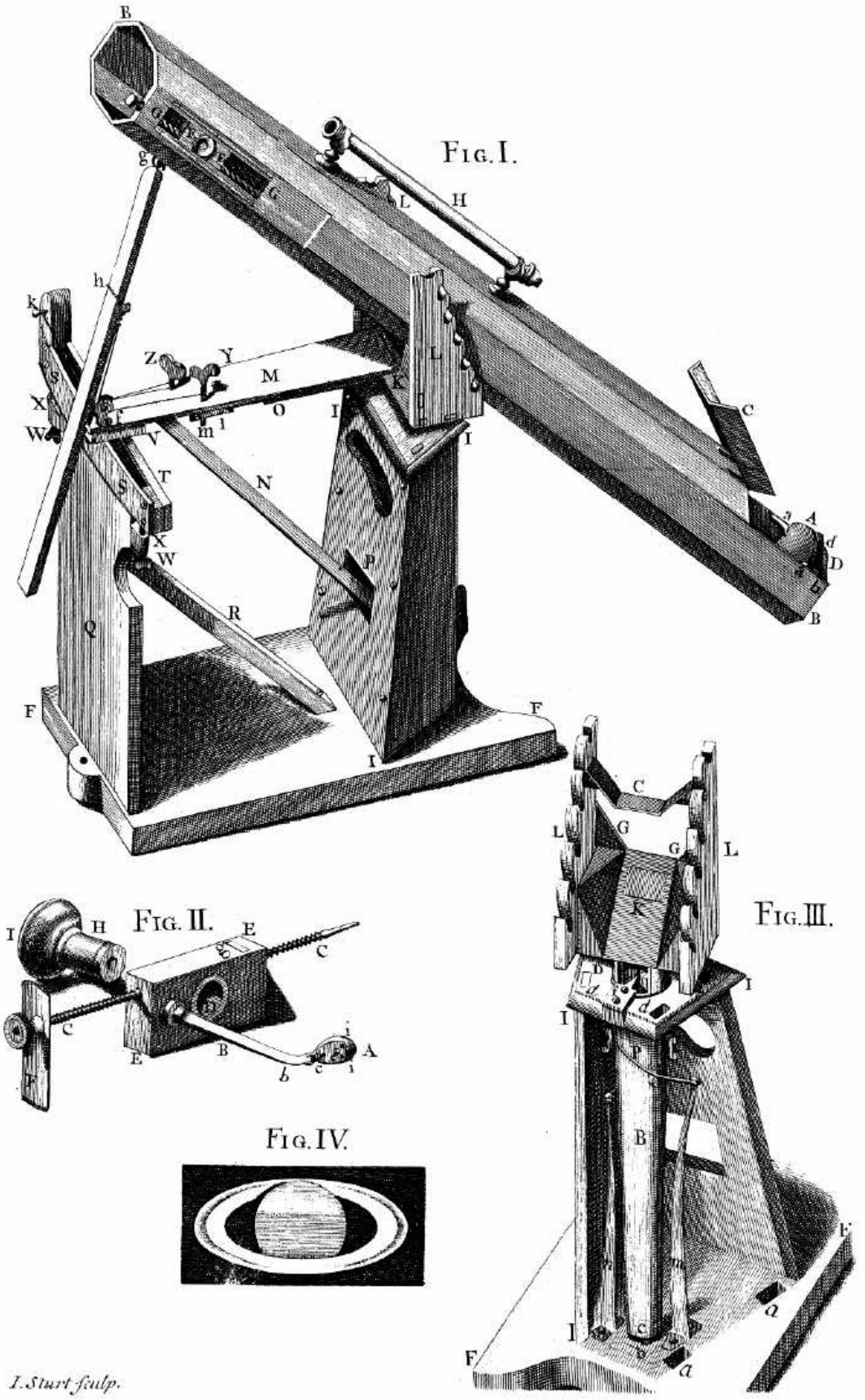
The oval plane secondary speculum measured about 7/10 x ½-inch and was 1/16 of an inch thick. It was fixed to a small brass plate attached to a thin and flat brass arm with its thin section parallel with the longitudinal axis of the telescope in order to minimise or obviate optical effects, while the other end of this brass arm was attached to a sliding unit which fitted into wide grooves along the length of a rectangular aperture in the side of the tube. With an eyepiece inserted in this unit, focusing was achieved by turning a long screw working on an inserted nut to move the entire unit with the secondary speculum and the eyepiece attached. The head of this focusing screw was fixed to the rim of the tube with a brass plate to prevent its moving out.

The octangular tube of the telescope, about 6 feet long, was dyed black on the inside to absorb stray light and to prevent internal reflections. In addition, a small brass plate, with a hole a little larger than the diameter of the optical cone at that point, was affixed to the inside of the sliding unit to prevent the passage of light except that reflected by the secondary speculum, while each eyepiece was fitted with a cup-shaped attachment to block extraneous light. Five eyepieces were provided for astronomical use (inverted image) – a ⅓-inch producing a magnification of about 186x, a 3/10-inch magnifying about 207x, an 11/40-inch magnifying about 226x, and two others magnifying about 200 and 220x – and three eyepieces for diurnal use (erect image), magnifying about 125x. Hadley also considered the inconvenience of locating objects with high magnification, and attached a finder – a 'common dioptrick telescope' of about 18 inches focus and with crosshairs. He did not mention how, nor by whom, the eyepieces and the finder were manufactured, but it is possible that he made them himself.

The base of the mount was about 3 feet long and 14 inches wide, and on this base was fixed an upright four-sided box about 2 feet high. Fitted into this was a turning pillar, at the bottom of which was an iron pivot sitting in a thick brass plate. The top of the pillar carried a head with two cheeks, each about 14 inches high, and each with five slots for adjusting the height of the telescope, which was fitted with iron trunnions. Extending from the head to a vertical board, strengthened with a brace attached to the base, was a horizontal arm, strengthened with a brace attached to the pillar. The vertical board carried a slightly curved rest on which the end of the flat arm moved from side to side, and the telescope could be moved with lines attached to butterfly screws and passing through a system of small rollers and pulleys. As the part of the telescope below its pivot point was slightly heavier than the part above it, observational altitude could be increased by turning the appropriate screw so that the lower end of the telescope moved downwards under it own weight, while turning the screw in the opposite direction would wind in the line and lower the top end of the telescope. For adjustment in azimuth, two very strong vertical springs, attached to the base, exerted tangential force to rotate the pillar and move the telescope, while the other butterfly screw and line controlled the rate of movement. In effect, it was a form of drive. In addition, the butterfly screw could be turned in the opposite direction to wind up the line and reverse the movement of the telescope. Consequently, with the two butterfly screws acting as slow-motion controls conveniently placed on the horizontal arm, an object could be followed very easily.

This instrument was meticulously designed and manufactured to the greatest possible accuracy and efficiency, with a primary speculum worked to a parabola, an appropriately sized secondary speculum worked to a plane, sufficient aperture for good resolution, optics fitted in ways which prevented movement or stress and allowed for collimation, adjustments for balancing, convenient slow-motion adjustments in altitude and azimuth, a finder, several eypieces, facilities for preventing the intrusion of unwanted light, and a solid and stable mount. It was the first reflecting telescope to incorporate all the operational requirements for practical observational astronomy.

With the passing of time, Hadley's telescopes could not be traced and eventually were thought to be lost; but in 1834, during the preparation of a catalogue of instruments and equipment belonging to the Royal Society, a small box was found containing specula and eyepieces – the remnants of the telescope which he had presented more than a century earlier. The mirror was dull and tarnished, and there was evidence of the spots and pits which he had described. Forty years after being rediscovered, these remnants were placed in the collection of the South Kensington Museum, and were catalogued as 'Metal for a Newtonian reflector, with several wooden eyepieces, but without tube or mounting, by Hadley'.



I. Sturt sculp.

σ Orionis

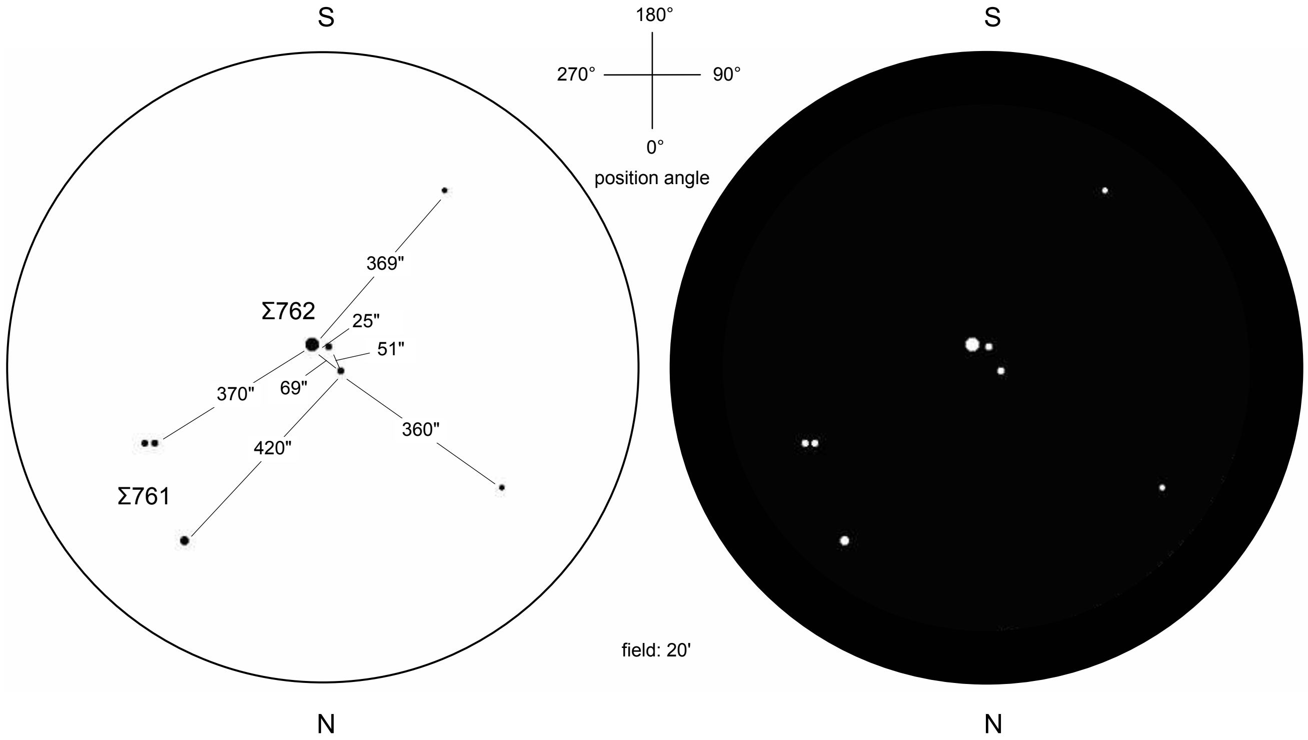
Orion's rich complement of deep-sky objects includes many double and multiple stars that can be observed with relatively small apertures. One of the easiest to find is σ Orionis (Flamsteed 48) – a multiple star situated a little less than 1° *sp* ζ, the easternmost star of the Belt, which itself is a close double with a wide third component. The position angles and separations of six of the components of σ were first measured by William Herschel in 1779. Herschel classified double stars according to angular separation – class I being the closest and class VI the widest – and σ Orionis was designated as the triple stars H II.10 (σ1) and H II.11 (σ2), the classification being defined by the closer pairs. Herschel also suspected the primary of H II.11 to be variable, and recorded two other faint stars *nf* and *sf*.

No further measures were made until forty years later, when James South and John Herschel, during their joint double-star survey of 1821–23, designated H II.10 as Sh 63/64 and the two closer components of H II.11 as Sh 66, the third component being omitted. Soon afterwards, Wilhelm Struve remeasured the system, to which he assigned the numbers 761 and 762, including a previously unmeasured fourth component in the latter.

During the ensuing six decades the system was measured by Smyth, Dawes, Dembowski, and several others, and in 1888 S. W. Burnham, using the Lick Observatory 12-inch Clark refractor, discovered a fifth component (β1032) of Σ762. At that time the separation was only 0″.26, which later proved to be its maximum separation, and measures over the following ten years – chiefly by Burnham, Schiaparelli, Aitken, and Bryant – indicated retrograde motion.

In 1904, Frost and Adams, at Yerkes Observatory, announced their discovery of the spectroscopic binary nature of the principal star of Σ762. Auwers determined an annual proper motion of 0″.024 in the direction of 297°.7 for the primary, which would have moved it about 1″.7 relative to its companions during the seventy or so years following Struve's measures. This displacement was not observed, however, so all the components of Σ762 must be part of the same system, although Σ761 is a separate group.

σ Orionis is therefore a pair of multiple stars with eleven components. The diagrams show the system (with approximate distances) but do not include Struve's fourth component of Σ762, β1032, or the spectroscopic binary companion.



The companion of Sirius

In 1844, Friedrich W. Bessel investigated a new problem 'whose solution will cost much labour and a long period of time, viz. the problem of determining the special motions of a star.' His analysis was based on the Right Ascension of Sirius and the declination of Procyon recorded in his *Tabulae Regiomontanae* and by Maskelyne (Greenwich), Pond (Greenwich), Piazzi (Palermo), Struve (Dorpat), Argelander (Bonn), Airy (Greenwich), Henderson (Cape of Good Hope), and Busch (Königsberg) during the period 1755–1844. (A few of his equations are shown at right.) Periodicity in the motion of these two stars, he concluded, was due to the gravitational effects of unseen companions: 'If we were to regard Sirius and Procyon as double stars, the change of their motions would not surprise us; we should acknowledge them as necessary, and have only to investigate their amount by observation.'

In 1851, Bessel's study was continued by Christian Peters, who determined that the supposed companion of Sirius had an orbital period of 50.093 years, that it moved in a very eccentric

$$0 = \frac{d^2x}{dt^2} + \mu\frac{x-\xi}{\rho^3} + m_n\frac{x-x_n}{r_n{}^3}$$

$$0 = \frac{d^2y}{dt^2} + \mu\frac{y-\eta}{\rho^3} + m_n\frac{y-y_n}{r_n{}^3}$$

$$0 = \frac{d^2z}{dt^2} + \mu\frac{z-\zeta}{\rho^3} + m_n\frac{z-z_n}{r_n{}^3}$$

$$0 = \frac{d^2\xi}{dt^2} + m\frac{\xi-x}{\rho^3} + m_n\frac{\xi-x_n}{\rho_n{}^3}$$

$$0 = \frac{d^2\eta}{dt^2} + m\frac{\eta-y}{\rho^3} + m_n\frac{\eta-y_n}{\rho_n{}^3}$$

$$0 = \frac{d^2\zeta}{dt^2} + m\frac{\zeta-z}{\rho^3} + m_n\frac{\zeta-z_n}{\rho_n{}^3}$$

$$\frac{1}{2}\frac{d^2\varphi}{dt^2}tt + \text{etc.} = \frac{m_n tt}{2}\left(\frac{1}{r_n{}^3} - \frac{1}{\rho_n{}^3}\right)\frac{r_n}{\rho}\sin s_n \cos p_n$$

$$0 = \frac{d^2(y-\eta)}{dt^2} + (m+\mu)\frac{y-\eta}{\rho^3} + m_n\left\{\frac{y-y_n}{r_n{}^3} - \frac{\eta-y_n}{\rho_n{}^3}\right\}$$

$$0 = \frac{d^2(z-\zeta)}{dt^2} + (m+\mu)\frac{z-\zeta}{\rho^3} + m_n\left\{\frac{z-z_n}{r_n{}^3} - \frac{\zeta-z_n}{\rho^3}\right\}$$

orbit, and that it had passed near the primary in 1841. In 1861–62 this analysis was extended by Truman Safford and Arthur Auwers, working independently. Magnitudes of companions, however, could not be determined without observations. Sirius, of visual magnitude –1.46, is about 10,000 times brighter than its companion at magnitude 8.4, while the difference in brightness of Procyon and its companion, with visual magnitudes of 0.34 and 12.9, is far greater.

On 31 January 1862, Alvan Graham Clark was testing the 18½-inch object glass of the telescope commissioned by the University of Mississippi, but which, due to the Civil War, was redirected to Dearborn Observatory. With Sirius just outside the field of view, like the approaching dawn, a close and much fainter star appeared first. This was the discovery observation of the companion of Sirius, and Clark immediately sent a brief report to George P. Bond at Harvard College Observatory.

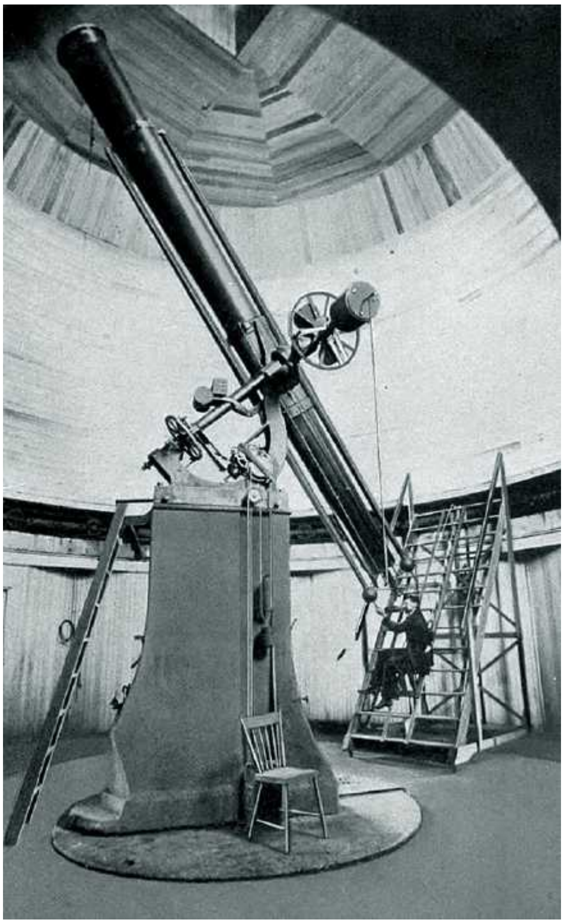
Due to adverse weather, Bond was not able to confirm the presence of the companion until 7 February, when he obtained measures with the 15-inch Merz refractor: position angle, 85º 15' ± 1°.1; distance, 10″.37 ± 0″.2.

> When the images are tranquil the companion is distinctly enough seen, but these moments are quite rare, as the low altitude of Sirius exposes it to almost continual atmospheric disturbances. I shall take the first favourable opportunity of repeating the measures which not improbably may stand in need of correction, especially in the distance.

Subsequently, Bond obtained additional measures on 10 and 16 February, 11 and 19 March, and 12 April, but stated that it ‘remains to be seen whether this will prove the hitherto invisible body disturbing the motions of Sirius.’

15-inch Merz refractor, Harvard College Observatory.
With Richard E. Schmidt and Owen Gingerich.
(Courtesy Richard E. Schmidt, United States Naval Observatory.)

On 27 January, four days before the discovery observation, Jean Chacornac, using J. B. L. Foucault’s 80-cm silver-on-glass reflector, had searched for the supposed companion but could not see it. News of the discovery reached Paris about the middle of March, and Charconac therefore searched for the companion again until on 20 and 25 March he observed and measured it. On subsequent occasions he saw it again, but when he could not see it he attributed it to poor seeing. (The Parisian atmosphere was the primary reason why Foucault’s telescope was later relocated to Marseilles.)



18½-inch Clark refractor, Dearborn Observatory.

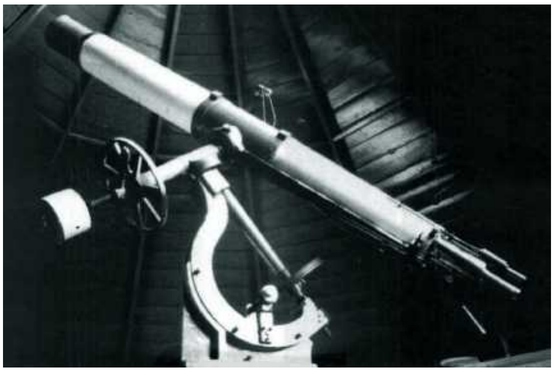
On 8 March, Lewis M. Rutherfurd, in New York, read Bond’s report, and on that evening, using an 11¼-inch refractor by Fitz, he observed the companion. Subsequently, in March and April, several measures were obtained by himself and independently by his assistant, Mr Wakely:

> Since hearing of the existence of this star I have never looked for it in vain; its difficulty is not occasioned by faintness, but by its proximity to so bright an object as Sirius ... On the 6th of April, within five minutes after sunset, I set the circles of the equatorial and found Sirius, the daylight being abundant to read the divisions, the companion was then quite distinctly visible; and on the 10th of April Mr Wakely’s measures were taken by daylight.

On 11 April, William Lassell observed it with his 48-inch speculum-metal reflector in Malta. He obtained a distance measure of only 4″.92, and was surprised by the large difference between this measure and those obtained by Bond and Chacornac:

> I cannot accept the conclusion that there can have been a real motion in the star sufficient to reconcile these measures. No doubt Sirius will be eagerly watched by astronomers who possess telescopes capable of showing the companion, to ascertain whether it is really attendant upon the large star, or whether Sirius is only optically double.

In January, February, and March 1864, he and Albert Marth independently obtained several measures that were much closer to Bond’s results, but again there were disparities, even though they had both used the 48-inch.



The author and W. R. Dawes' 8¼-inch Clark refractor in 1983.

In 1864, William Rutter Dawes observed and measured the companion with his 8¼-inch Clark refractor and Dollond filar micrometer:

> On March 24th the air was rather thick, but the image of the star was unusually quiet and well defined; and though the companion was faint, yet there could be little doubt of its being really a star. To place this beyond suspicion, I turned the object-glass round into various positions, by unscrewing its cell, without any variation in the place of the small star, and also turned the eyepiece, and altered the situation of the object in the field, with the same result.

Measures with the micrometer fitted with thick wires and thin webs produced a position angle of 84°.86 and a separation of about 10". On the following night, however, Dawes obtained a much better view. The air was clearer, Sirius and its companion were well defined, and he obtained measures which 'fully confirmed the reality of the previous night's observation, and convinced me that good measures might be obtained in a suitable state of the air.' After reading reports and observing the companion he concluded that observation of the faint and close attendants of a star such as Sirius, particularly when at a low altitude, is 'rather a test of the state of the atmosphere than of the quality of the telescope.'

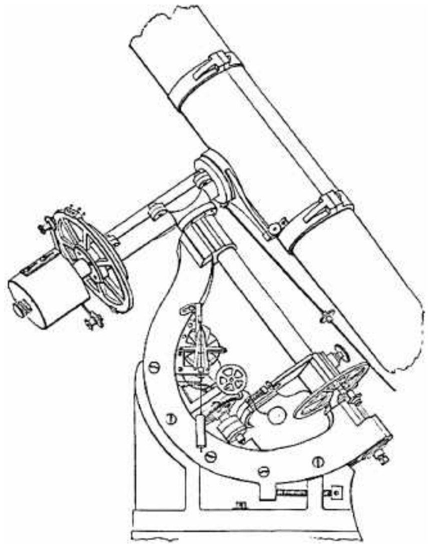
The 8¼-inch, delivered to Dawes in May 1859, was the fifth object glass and first complete instrument that he purchased from the Clarks. The design of the equatorial head is the same as that of the 18½-inch refractor (produced two or three years later), and the drive was efficient and reliable:

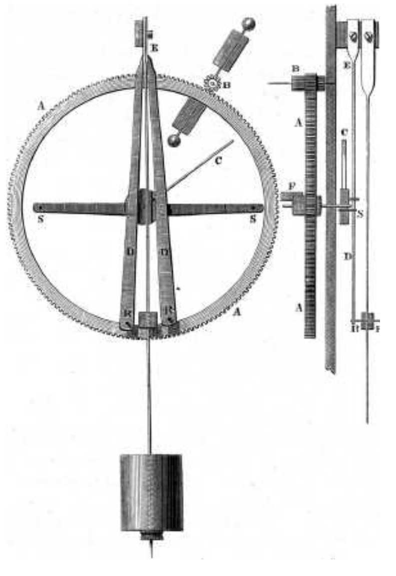
> While the speed of the clock is regulated by the vibrations of the half-seconds pendulum, the action of the pendulum on the wheelwork is rendered smooth and equable by an ingenious application of Bond's spring governor; and so perfectly successful is this contrivance, that with the thread of the micrometer bisecting a star, and a power of 800 or 1000 on the telescope, no interruption or jerk from the escapement is perceivable.

(This drive was removed in 1925, and in 1964 an electric drive was fitted. See my paper, 'The 8¼-inch Clark refractor of the Temple Observatory, Rugby', *Journal of the British Astronomical Association*, 101 (1991), 343–50.)

At Pulkowa Observatory, where Sirius culminates at an altitude of only 13°.5, Otto Struve, using the 15-inch refractor by Merz und Mahler, obtained measures each year from 1863 to 1866. Friedrich Winnecke also obtained measures with the same instrument, though with several degrees difference in position angle, for which Struve provided a possible explanation:

> Perhaps this discrepancy might be explained by the very sensible prismatic image exhibited by Sirius in the low altitude in which it has been observed here, combined with a different sensibility for colours, of the eyes of the two observers.





Bond's spring governor.

The companion was also observed with much smaller instruments. In 1863, Richard Hodgson, using a 6-inch refractor, said he had seen it more than once on very fine nights. At about the same time, Hermann Goldschmidt, using a refractor of 46 Paris lines (fractionally less than 4.1 inches), announced to the Académie des sciences that he had observed it and had also seen five other faint stars at distances varying from 15" to 1'. Dawes responded:

> It seems scarcely possible that *some* of these at least should not have been seen with Mr Clark's magnificent instrument; for on turning upon Sirius my equatoreally-mounted refractor, of 8¼ inches in aperture, also made by Mr Clark, I immediately perceived Goldschmidt's star, called *d*, which is by no means a difficult object; but the condition of the bright star itself was such as to preclude all hope of discerning anything much nearer to it. The distance of the star *d* is, however, too great (about 1½') to make it an object of any particular interest.

Otherwise, Goldschmidt's additional faint stars were not confirmed, even though he was a reliable observer. (Using, in turn, 2-inch, 2.7-inch, and 4.1-inch refractors on the balcony of his apartment in Paris, between 15 November 1852 and 5 May 1861 he discovered fourteen asteroids.)

In Bond's first report, while acknowledging that the low altitude of Sirius and consequent atmospheric disturbances were a hindrance, he considered that the quality of the 18½-inch object glass was the primary factor in the discovery:

> It must be regarded as the best possible evidence of the superior quality of the great object-glass, that it has served to discover this minute star so close to the overpowering brilliancy of Sirius. A defect in the material or workmanship would be very sure to cause a dispersion of light which would be fatal to its visibility.

This could be said of instruments of any size or aperture, however. Assuming high-quality optics, a double star with components separated by several arcsec and not too large a difference in magnitudes is observable with a 2-inch refractor, but the enormous difference between the magnitude of Sirius and of its companion is a considerable impediment. Dawes believed that the very best atmospheric conditions were necessary to see the companion. If Sirius were at a higher altitude it would be seen without any difficulty, and he considered that Goldschmidt's observations proved this.

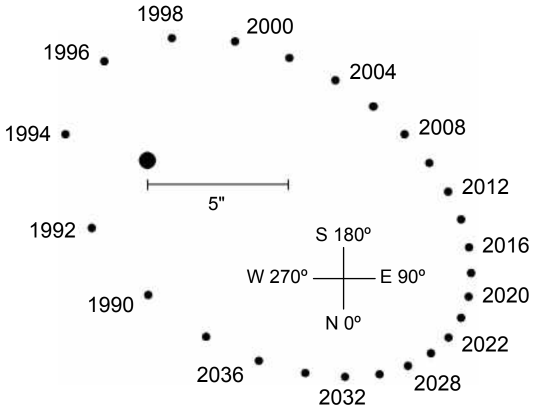
On 24 January 1866, George Knott turned his 7⅓-inch refractor (with a Clark object glass purchased from Dawes) on Sirius, and was 'surprised to find the small companion, notwithstanding bright moonlight, a tolerably conspicuous object.' He therefore obtained measures, and on 2 February he obtained additional measures with the aperture stopped down to 6½ inches. Furthermore, he could still see the companion when the aperture was stopped down to 5 inches, and was 'quite inclined to indorse the opinion expressed by Mr Dawes that the visibility of the small star is dependent rather on the condition of the atmosphere than on the size of the telescope.'

In 1879, Sherburne W. Burnham measured the companion with the Dearborn Observatory 18½-inch refractor. He noted that it had been measured by many observers on numerous occasions every year since 1862:

> Once discovered, it was readily seen and measured with the same instruments with which it had been vainly looked for before. I have seen it repeatedly with my 6-inch Clark refractor; but a steady air is necessary with any moderate aperture, because of the great brilliancy of Sirius, which overpowers the light of the small star, and because of its low altitude in northern latitudes. Probably in the southern hemisphere a good 5-inch object glass would show it satisfactorily.

The latest orbit computed by Auwers at that time, based on all available observations, produced a period of 49.4 years. However, the calculated position and distance for the period 1862–78, when compared with the actual measures, showed that the angular motion of the real star was more rapid than that of the theoretical star but with a smaller change in distance, indicating a period of more than 50 years.

Calculated			Observed			
	°	"		°	"	
1862.0	85.4	10.10	1862.2	84.6	10.70	Bond
			62.2	85.0	10.09	Rutherfurd
			1863.2	82.5	10.15	Struve
1865.0	79.9	10.78	1865.2	77.2	10.60	Struve
			65.2	76.8	10.77	Förster
			65.2	75.0	10.07	Secchi
1868.0	75.0	11.15	1868.2	70.2	11.26	Vogel
			68.2	69.5	11.35	Bruhns
			68.3	71.6	10.95	Engelmann
			1869.2	68.6	11.26	Dunér
1871.0	70.3	11.20	1871.2	64.0	11.21	Dunér
			1872.2	59.8	11.14	Dunér
			72.2	67.7	11.55	Newcomb
			1873.2	65.8	11.12	Hall
			73.2	60.9	10.65	Dunér
			73.9	59.4	12.27	Hall
1874.0	65.5	10.95	1874.2	59.0	11.46	Newcomb
			74.2	58.7	10.99	Holden
			74.2	57.9	11.10	Hall
			1875.2	57.1	10.81	Dunér
			75.2	56.6	11.41	Newcomb
			75.2	56.3	11.08	Hall
1876.0	62.1	10.59	1876.1	54.9	11.82	Holden
			76.2	55.2	11.19	Hall
			1877.1	53.1	11.20	Stone
			77.2	52.8	11.35	Holden
			77.3	53.4	10.95	Hall
1878.0	58.4	10.05	1878.0	52.4	10.83	Burnham
			78.1	50.6	11.07	Holden
			78.2	51.7	10.76	Hall
			1879.1	50.7	10.44	Burnham



The current calculated orbital period of Sirius B (as it came to be known) is about 50.1 years. At periapsis the distance is less than 3", but observing opportunities are now more favourable as it approaches apoapsis at a distance of about 11" and a position angle of about 80°.

The companion of Procyon proved far more elusive, as all supposed sightings were ghost images or otherwise invalid observations, until in 1896 it was observed by John Schaeberle, using the Lick Observatory 36-inch refractor. With an orbital period of about 40 years, the current distance is about 5" and the position angle is about 335°.

I would be interested in knowing of visual observations of the companions of Sirius or Procyon (or both), especially if achieved without the use of an occulting bar or disc, webs or wires, the edge of the field, or filters.

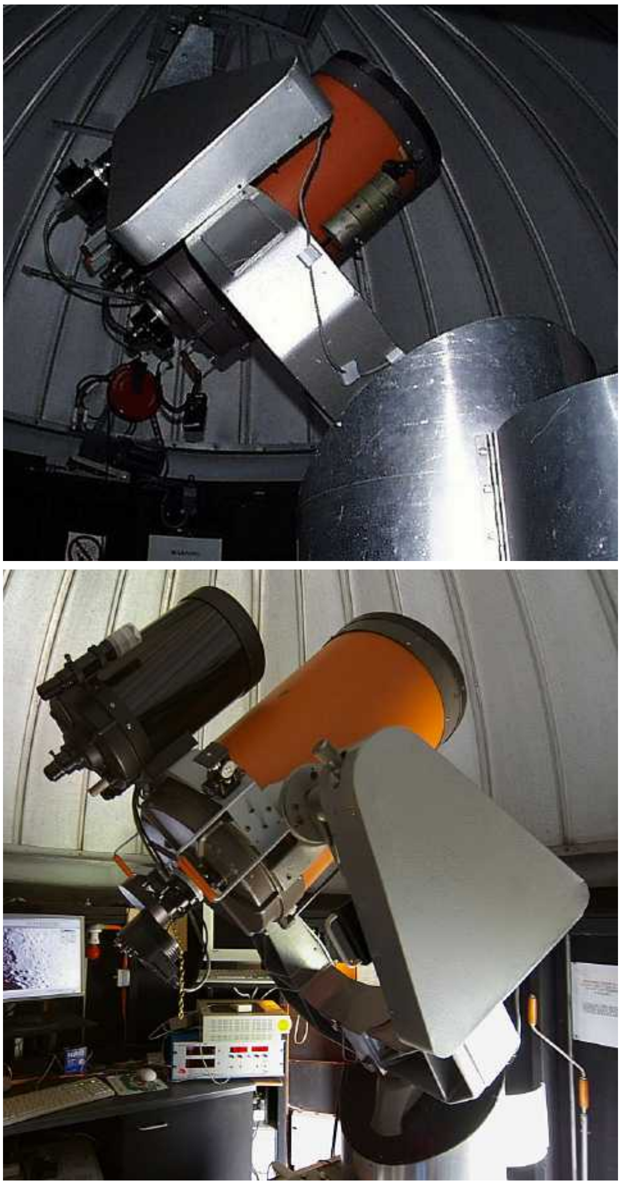
AE instruments at the University of Hertfordshire

Bob Forrest

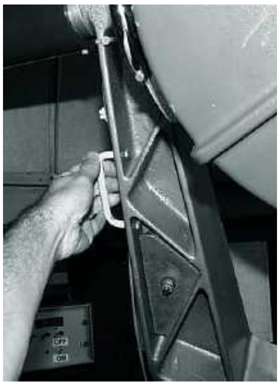
I was very interested to read about Alan Snook's work on the 14-inch AE reflector that was formerly in service at Sheffield University (*Occasional Notes* No. 2).

Regarding the fork, the University of Hertfordshire Observatory possessed two of these, set up by Rob Hysom. I am unable to date the earlier of these precisely, but I think it was in the late 1980s. It held a 14-inch Celestron Schmidt–Cassegrain optical tube, replacing its original standard mounting. The second one was made in 1989, together with an optical tube holding an existing AE 16-inch mirror with a new secondary made by Jim Hysom. I am sure of this date, as the dome in which it was newly installed was promptly demolished by the devastating storm of January 1990. As these forks were of different sizes, at least two patterns must have been made. I think it likely that there are other examples around, but have no knowledge of them. As Alan has stated, the design is beautiful and is far superior to the original fork of the 14-inch. Both were supplied with tangent-arm guiding drives. If my memory of AE's product range is correct, the heads of these were of type C, as distinct from Alan's more massive type D, though many details are similar. The photographs show the instruments at Hertfordshire Observatory. Simple sheet-metal covers were made to keep dust and detritus out of the working parts.

Concerning Alan's first article on the restoration of his 14-inch AE (*I&I News* New Series No. 29, 16 June 2017), I am intrigued by the issue of colour. Hertfordshire Observatory also had a couple of 6-inch AE Newtonians and a 10-inch, all dating, I assume, from 1970 or soon after. These were all anodised to a golden brown finish, so Alan's choice of colour may in fact be appropriate.



The 14-inch. The handles and sheet-metal covers on the fork, and the piggy-back support for the 8-inch, were fitted by the university.



(Above left) The 14-inch RA drive clamping nuts. The position encoder on the lower end of the polar axis was a retrofit by AE.

(Above) The declination clamp.

(Left) The polygonal counterweight fitted by AE to balance the tangent arm declination drive on the opposite side.

(Right) The 16-inch under a new and robust dome.

Using VHF radio transmissions to detect meteors ablating in the atmosphere

Ken Ginn

I have been involved in astronomy both at a professional level early in my career and more recently as an amateur astronomer as I approach retirement. I am also an electronics engineer with a broad range of experience in radio and electronic systems, and in addition I am a radio ham and have held the call sign G8NDL since 1977.

I have always been fascinated watching the various meteor showers that occur predictably throughout the year, when the visual spectacular draws my attention to these events during many late evenings and the early hours of the morning. However, with our famous British weather and not so dark skies these observations can often be clouded out and can prove disappointing. Therefore, to obtain some useful observations I turned my hand to radio observations using the GRAVES satellite tracking system located in France. This article describes a simple system which I have found easy to set up and operate, and with which useful observations can be made with a VHF receiver, a simple antenna, a computer, and appropriate software. The equipment can be purchased and is nothing special. I estimate that a set-up (not including the computer) costs less than £120 if the components are new, but less if secondhand.

Meteor scatter radio propagation

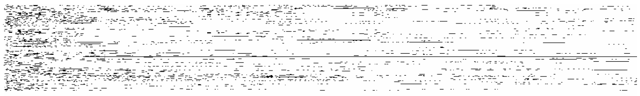
Meteor scatter radio propagation has been in use in amateur and professional realms for many years, with the sending of high-speed packet data transmissions. The received signal relies on the resultant ionised meteor trail to reflect the radio signal back to earth. This can be short-lived, and when heard on a radio speaker sounds rather like a short audible ping, or sometimes as a longer event of a couple of seconds. Communication distances of thousands of kilometres can be achieved by using this method.

GRAVES

The French GRAVES space surveillance system, operating on 143.050 MHz, is designed to track objects orbiting above French air space, such as satellites or space debris. This system, which forms part of the country's national security, maintains a database of satellites orbiting within 1,000 km above France.

There are two radio sites in France, separated by about 300 km: the transmitter sited at Broyes-les-Pesmes, and the receiver near Revest du Bion. The receiver does not have a direct radio tropospheric link with the transmitter, and instead receives signals originating from the transmitter and bounced back from orbiting satellites. The transmitter's signal is propagated skywards, while the receiver site is also looking for a skyward signal. Meteors leave short-lived ionised trails that act like a mirror, and part of the skyward GRAVES transmission is reflected back to earth during a meteor's ablation in the atmosphere; or as intended, the transmission is bounced back by a piece of space hardware at a higher altitude – even the International Space Station.

Observing the signals via radio (supplemented by information on GRAVES Internet sources), the transmitted signal is a single carrier with no perceivable modulation or data, so it is easy to monitor meteors ablating in the upper portions of the atmosphere that are normally well over the horizon. The receiver site is of no consequence for my observations, as I am only interested in the radio signal transmitted from Broyes-les-Pesmes.



SDR radios

I have an HF/VHF/UHF radio transceiver which was used in initial trials, but to be more practical I bought an SDR radio which suited my purpose and was cheaper. SDR radios are a fairly recent advance in technology, where the discrete sections of amplification, filtering, and demodulation of the received signal are now done with a digital processor, commonly a computer. This allows for a huge range of the spectrum to be tuned to with the selection of filters and demodulation schemes to be used, and the mass production of high-precision analogue-to-digital convertors has made this possible at reasonable prices. The audio signal is of primary interest, and is easily recorded with the SDR software or other audio software. An FM radio scanner, for example, will not work as well, and a receiver with Single Side Band (SSB) and selectable Upper Side Band (USB) is preferable. The receiver used in this exercise is an SDR play RSP1A powered off a PC USB port, with the computer running overnight during observations.

Antenna construction

The antenna is a 144/146 MHz vertically polarised three-element Yagi that I had in the loft, but it can be fabricated for a few pounds with odds and ends. Details of such antennae are available on various websites. If the antenna is to be sited outside where it is exposed to the elements, it is highly advisable to treat the wood with a preservative, and the electrical joints to the coaxial cable need to be protected against the ingress of water.

The antenna consists of a central wooden boom, with each of the elements being made of aluminium or copper tubing about ½-inch (12–15 mm) in diameter. Heavy-gauge wire can also be used for the antenna's elements. The coaxial cable (RG213 or UR67) is attached to the middle element, braid is attached to the lower element, and the inner conductor is attached to the uppermost element. The shortest element points in the direction of Broyes-les-Pesmes.

Computer

This is an old ITX computer – a spare that is easy to run overnight – incorporating an AMD E-350 D dual core 1.6 GHz processor with 4 GigaBytes of RAM running Windows 7 Ultimate and a 64-GigaByte solid-state hard drive.

Software

The software came with the SDR receiver and is just about capable of running on the old ITX computer. In some computers it is possible to record the incoming audio directly, via another separate piece of software, to the hard drive, without any additional leads on the computer. The SDR play software has a recording facility built in, and once the red record button is clicked this will start recording a *.wav audio file, with the file name being the time and date that the file was created. There is no necessity to synchronise files to times, though for accurate timing I find it best to synchronise the time with an Internet time server before observing. The SDR play software is launched and the parameters are set thus:

Local Oscillator: set to 0142.894.800 (142.894800 MHz)
Tune: 0143.048.400 (143.048400 MHz)
Mode: USB (Upper Side Band)
Sound card: matches the computer sound card (e.g. Realtek Digital Output)
Bandwidth: Input 2000000 and Output 8000

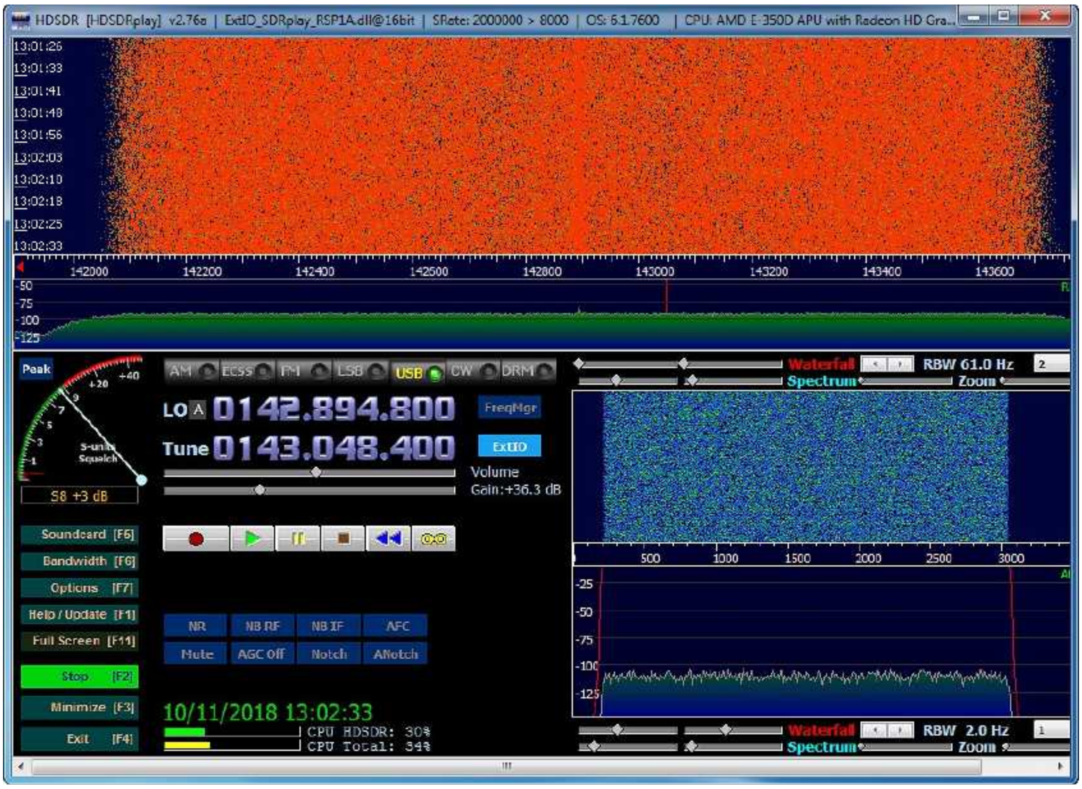
The frequency of interest is 143.050 MHz, so to make the GRAVES signal audible the Tune frequency is offset by –1.6 KHz, making the pings audible at 1.6 KHz.

In the display below, the orange waterfall is a slice of the electromagnetic spectrum from approximately 142.0 to 143.7 MHz, and the blue waterfall is the audio bandwidth being monitored, a section of 2.8 KHz. Both waterfalls show recent historical data where the speed of the displays and the colours can be adjusted in the software. The section at bottom right represents current audio data in much the same way as a spectrum analyser, with amplitude on the vertical axis and frequency on the horizontal axis.

Setting up and running

The three-element Yagi antenna, in the loft of my home in Kent, points in an approximately south-east direction, but this is a little off the direction to the transmitter due to the loft's structural woodwork, which inhibits direct alignment. However, the antenna has some forward gain, so even if it were off by as much as 30° it would make little difference in the received signal strength.

Shortly before 21:00 UTC I start setting up, which takes very little time. I switch the computer on, set its clock via the Internet if needed, run the software with the SDR receiver connected, connect the SDR receiver to the antenna, press record on the software, and wait until morning. The recording is then stopped and the software closed down, and analysis can take place. I have never been tempted to close down the SDR software without stopping the recording, as I am very aware that this might ruin eight hours' observations.

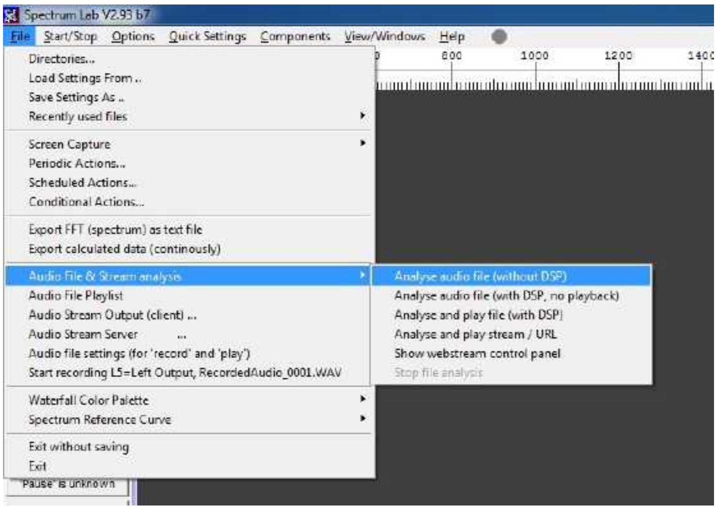


HDSDR [HDSDRplay] v2.76a | ExtIO_SDRplay_RSP1A.dll@16bit | SRate: 2000000 > 8000 | OS: 6.1.7600 | CPU: AMD E-350D APU with Radeon HD Gra...

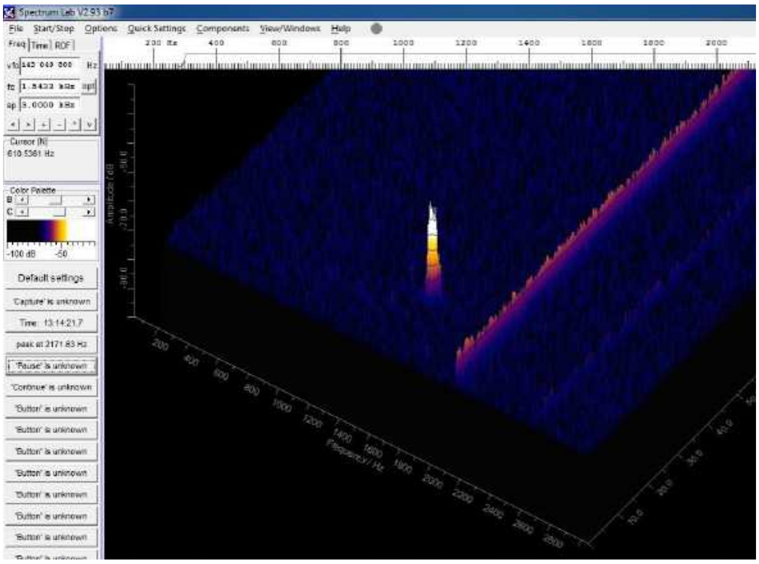
LO A 0142.894.800
Tune 0143.048.400
Volume
Gain:+36.3 dB
S8 +3 dB
RBW 61.0 Hz
RBW 2.0 Hz
10/11/2018 13:02:33
CPU HDSDR: 30%
CPU Total: 54%

Audio signal analysis

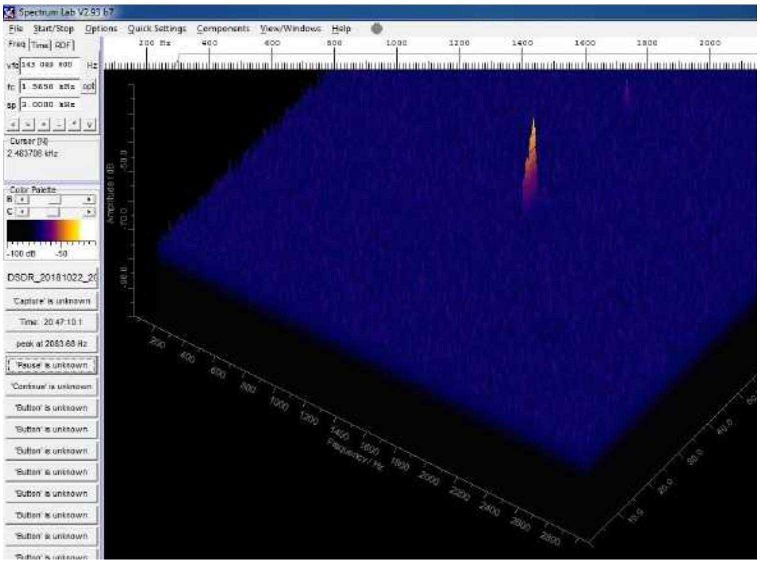
The software that I use to playback and analyse the *.wav file recorded overnight is Spectrum Lab v2.93 b7, written by Wolfgang Buescher (ham radio call sign DL4YHF). Audacity software is a useful tool for examining the overall data, but is not essential. The *.wav file can be selected as shown at right. Click on 'Audio File & Stream analysis', then 'Analyse file (without DSP)', and go to the directory where the *.wav file is stored. The file will play in fast time, but sufficiently slowly to count the number of pings over the monitoring period. Analysis of a night's observations could run for fifteen minutes.



To obtain meaningful data, adjust the brightness (B) and contrast (C) controls on the left-hand side of the window. I prefer to run the baseline noise in the blue, and any pings appear out of the noise as a bright-coloured short peak. The two parallel lines indicate noise which is a portion of broadband noise coming from an unknown source. This may occur on subsequent observations or may just be a one-off event. Unfortunately, the radio spectrum is rather like the dark skies that astronomers always hope for, so in some respects it is a noisy place. A number of signals will be received, some of which may be from aircraft or orbiting satellites – and hopefully, some will be from meteors ablating in the atmosphere. The illustration shows a ping at 1.2 KHz and two interfering signals at 1.6 and 2.3 KHz.



This illustration shows what can be observed and recorded with this simple arrangement – in this case, a large signal preceded by a much smaller signal, captured at approximately 23:32 UTC on 22 October 2018, during the Orionids meteor shower.



These brief details of my installation show that with little equipment some meaningful measurements can be made, though a larger dedicated system can be installed by utilising a bigger radio antenna with a larger gain. Details of equipment and downloadable software are available at these websites.

SDRplay RSP1A
https://www.sdrplay.com/rsp1a/

Spectrum Lab v2.93 b7 audio signal analyser
https://www.qsl.net/dl4yhf/spectra1.html

Audacity audio processing and editing software
https://www.audacityteam.org/download/

Swanley, Kent G8NDL@protonmail.com

Appulse of Venus and Jupiter

Bedfordshire, dawn, 22 January 2019. Linton Guise writes: ‘Overnight rain clouds slipped away to the east just in time to reveal the closest approach of Venus and Jupiter. To the lower right, Antares and the head of Scorpio are visible. Standing in the foreground is the magnificent oak tree near the boundary of the cricket field on The Green at Ickwell, illuminated by the setting Moon.’ In Peter Hudson’s photograph, Ganymede and Callisto are visible.

Erroneous discoveries

A large meteor

The Times, 1863

> Sir – A large meteor was seen to-night at 8.27 moving very slowly along the northern horizon from west to east, at an altitude of about 8 deg. It was at least three times as brilliant as Venus, remaining visible for nearly five minutes, moving slower than any hitherto observed. I should be glad to receive observations made at more favourable stations.
>
> Thomas Crumplen
> Mr Slater’s Observatory, Euston Road August 10
>
> Sir – The ‘large meteor’ seen by Mr Crumplen on Monday evening at 8.27, three times as brilliant as Venus, and moving from west to east, was a fire balloon sent up shortly after 8 o’clock from the Eton and Middlesex Cricket-ground, Primrose Hill, as a finale to some athletic sports which had taken place during the afternoon.
>
> B.C.C.
> St John’s Wood August 12

This mistake is perhaps excusable when it is considered that in 1863 there were no aircraft or artificial satellites.

A new star

Comptes rendus, 1891

In January 1891, Edmond Lescarbault, the ‘discoverer’ of the supposed intramercurial planet Vulcan, informed the Académie des sciences that he had discovered a new star in Leo. Remarkably, and without any confirmation, this was announced with the publication of a short paper in *Compte rendus*, under the title ‘Observation d’une étoile d’un éclat comparable à celui de Régulus et située dans la même constellation’:

> J’ai l’honneur de vous adresser le résumé de l’observation d’une étoile comparable a Regulus par sa grandeur et par son éclat; elle est située dans la même constellation; je ne l’avais jamais aperçue jusqu’à ce jour. Elle se trouve au-dessous de θ du Lion, sur le prolongement de la ligne qui joint δ a θ, à une distance de θ double de celle qui sépare ces deux étoiles et au-dessous de la ligne qui va de σ à χ, à peu près également éloignée de chacune d’elles. Je n’ai pu encore l’observer qu’à l’oeil nu, les 10 et 11 Janvier, vers une heure du matin; malgré le grand affaiblissement de mes yeux, je crois avoir bien vu et n’avoir pas été victime d’une illusion. Ce n’est que par estime que j’attribue à l’étoile, soit nouvelle, soit temporaire, qui est peut-être une étoile dont l’intensité et l’éclat auraient presque subitement prodigieusement augmenté, les quantités suivantes pour sa position:
>
> | | |
> |---|---|
> | Ascension droite | 11h 4m |
> | Déclinaison boréale | 6º |
>
> Dans le voisinage de l’étoile que je signale, les étoiles de quatrième grandeur étaient à peine perceptibles à l’oeil nu. Dans les Atlas et les Cartes du Ciel que je possède, je n’ai trouvé aucune étoile au lieu que je viens d’indiquer.

Lescarbault declared that he had ‘seen well’ and had ‘not been the victim of an illusion’; but at the following meeting of the Académie, Camille Flammarion pointed out his error:

> M. Flammarion fait observer que l’astre signalé le 11 janvier par M. Lescarbault dans la constellation du Lion, comme une étoile nouvelle, n’est autre que Saturne.