

# Halley and his maps of the to

Jay Pasachoff describes the pioneering work of Halley about the 1715 and 1724 eclipses, and relates it to the total solar eclipse of this August 11.

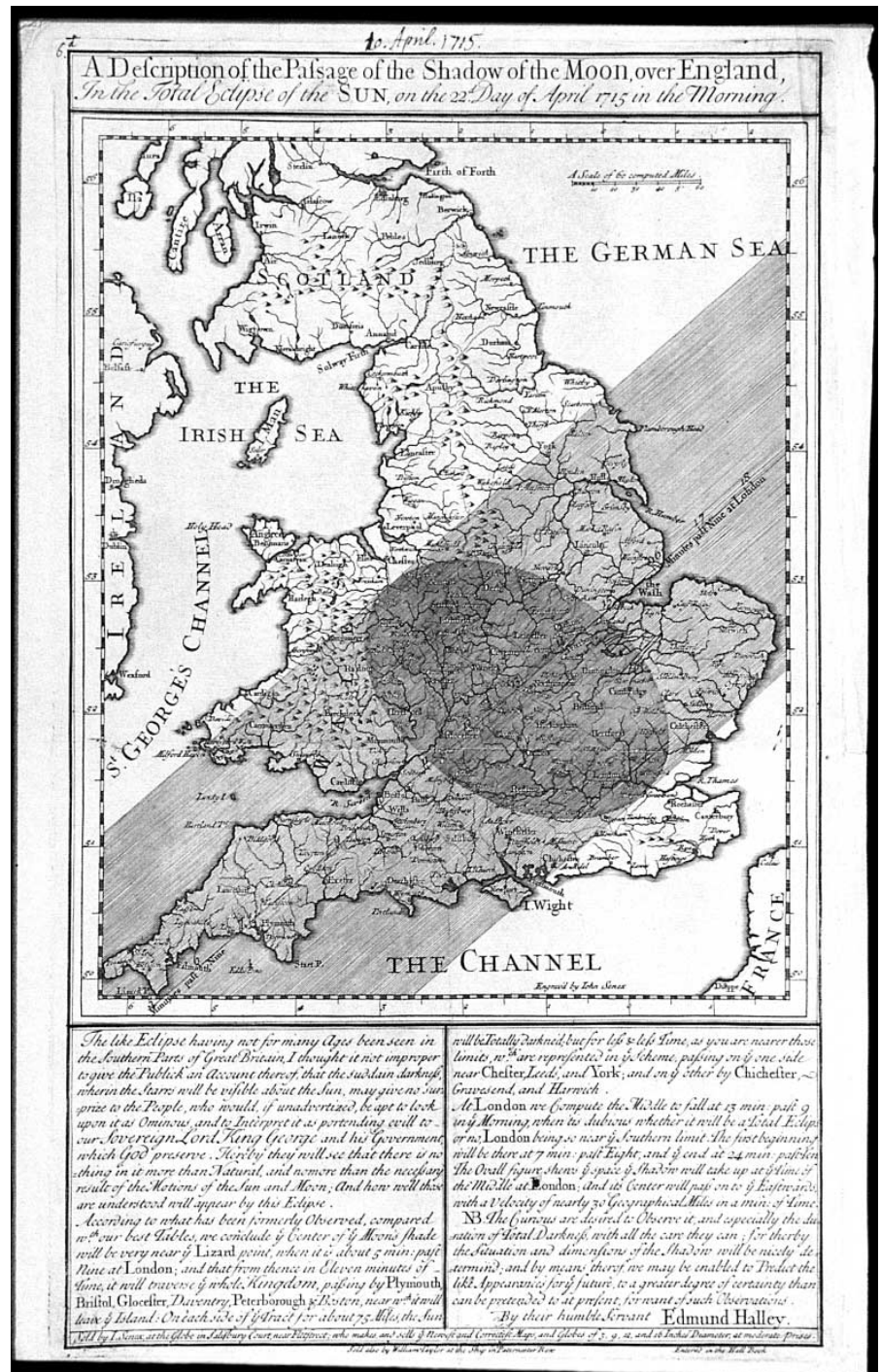
On 11 August 1999, a total eclipse of the Sun will sweep across Europe, from southern England to the south-east. While looking over Edmond Halley's 18th century eclipse maps, I was struck by the similarity of the 1999 eclipse path to that of 11 May 1724.

Halley drew his first eclipse map for the eclipse of 1715. Owen Gingerich (1981, 1992) states his belief that this 1715 map was the first map to show the path of a total eclipse from above. Eclipses had long been pictured from below. For example, I have an almanac/calendar from 1478, written by Jacob Pfaff, that contains drawings of partially eclipsed Suns from that date through 1551. Two early-1600s oil paintings by Rubens, *Elevation of the Cross* (1610) from Antwerp Cathedral and *Coup de Lance* (1620) from the Art Museum in Antwerp, the Koninklijke Museum voor Schone Kunsten, contain prominent partial eclipses, with the full, dark disk of the Moon visible, even though it would not actually be visible to an observer. Similarly, the great star atlas of Johann Bayer from 1603 shows the constellations as we see them looking up from the Earth, while the later impressive star atlas of Johannes Hevelius from 1687 shows God's view, the view from above.

Harvard's Houghton Library of rare books has four versions of Halley eclipse maps. They are broadsides, pictures and text printed on one side of single sheets of paper. There is a long history of astronomical subjects being treated on broadsides. The art historian Roberta J M Olson and I (Olson and Pasachoff 1989), for example, discussed images of comets on 16th- and 17th-century German broadsides; see Olson and Pasachoff (1998) for information on Halley and his work.

## The predictions of 1715

Each of the Houghton Library's broadsides is dated in the same, old-style hand, reported by Gingerich to be that of Narcissus Luttrell, who in the 18th century collected ephemera such as broadsides. In the same hand, the price of the broadside, sixpence, is given (6d). The first (figure 1), dated 10 April 1715, is captioned at the top: "A Description of the Passage of the



1: Halley's map of the predicted path of the 22 April 1715 eclipse. (With permission of the Houghton Library, Harvard University: EB7 H1552 715 d.)

*Shadow of the Moon over England, In the Total Eclipse of the Sun, on the 22<sup>d</sup> Day of April 1715 in the Morning.*

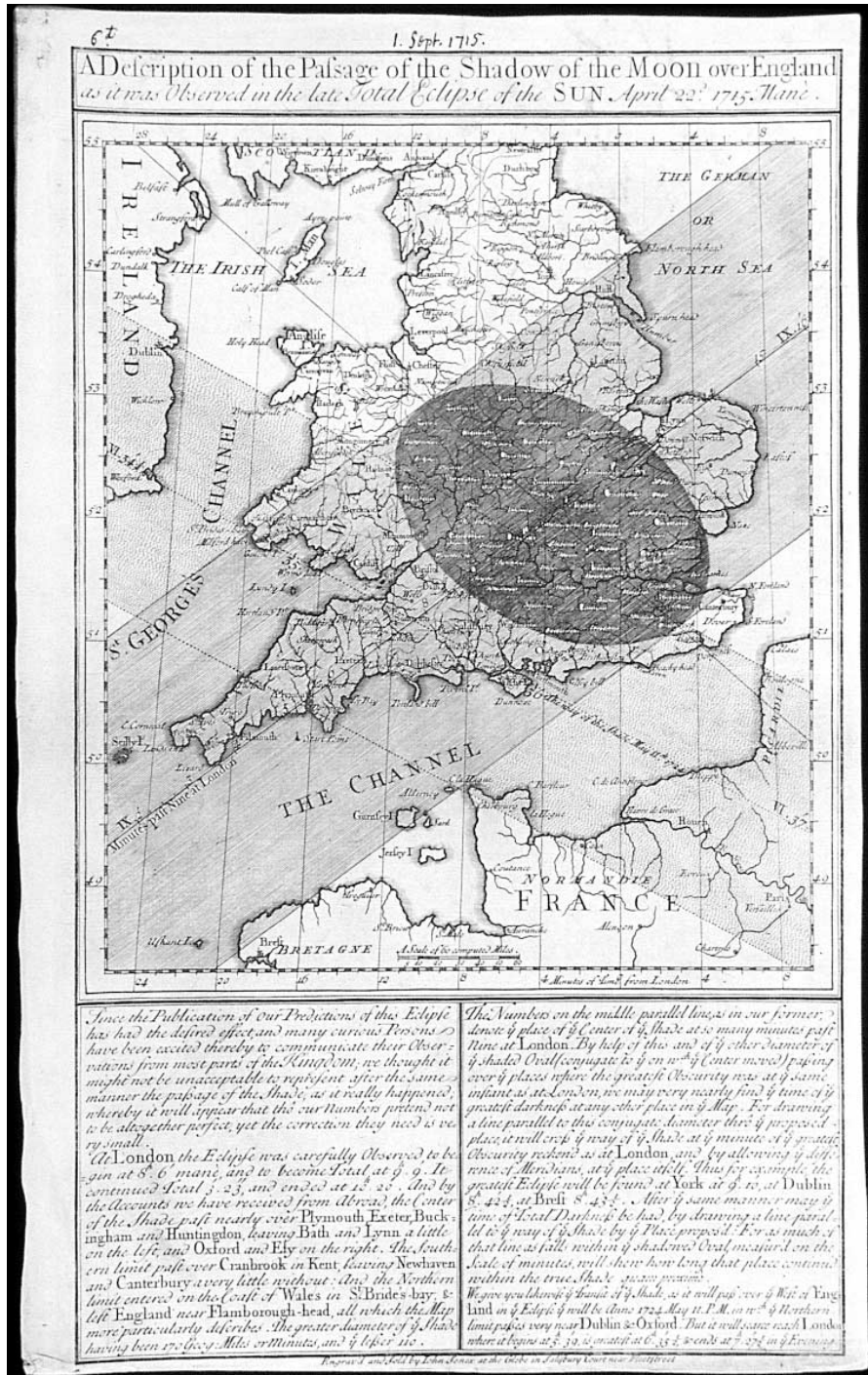
The eclipse path predicted for 1715 goes from southwest, hitting Cornwall, crossing London centrally, and has its the centre line exiting over the bay known as the Wash. (I have long enjoyed knowing that the "Ooze" runs into the Wash.) The elliptical shape of the

Moon's shadow is apparent; the range of partial phases is not specified. Below the figure, the text runs:

"The like Eclipse having not for many Ages been seen in the Southern Parts of Great Britain, I thought it not improper to give the Publick an Account thereof, that the suddain darkness, wherein the Starrs will be visible about the Sun, may give no surprize to the Peo-



# total eclipses of 1715 and 1724



2: Halley's map of the actual path of the 1715 eclipse with the predicted path for 1724 added, dated in hand 1 September 1715. (With permission of the Houghton Library, Harvard University: EB7 H1552 715d2.)

ple, who would, if unadvertized, be apt to look upon it as Ominous, and to Interpret it as portending evill to our Sovereign Lord King George and his Government, which God preserve. Hereby they will see that there is nothing in it more than Natural, and nomore than the necessary result of the Motions of the Sun and Moon; And how well those are understood will appear by this Eclipse.

According to what has been formerly Observed, compared with our best Tables, we conclude ye Center of ye Moon's shade will be very near ye Lizard point, when it is about 5 min: past Nine at London; and that from thence in Eleven minutes of Time, it will traverse ye whole Kingdom, passing by Plymouth, Gloucester, Daventry, Peterborough, and Boston, near which it will leave ye Island: On

Edmond Halley was perhaps the first, in 1715, to draw the path of an eclipse as seen from above, looking down at the Earth's surface. I compare four eclipse-path maps drawn for Halley: one before the 1715 eclipse, one with a corrected path after the eclipse and including the predicted path for the 1724 eclipse, a reissue of that map just before the latter eclipse, and a different map for that latter eclipse. These maps are in the collection of the Houghton Library of Harvard University. For comparison, I provide a current map of the 1999 total solar-eclipse path, which is similar to that of 1724.

each side of ye Tract for about 75 Miles, the Sun will be Totally darkned; but for less and less Time, as you are nearer those limits, which are represented in the Scheme, passing on ye one side near Chester, Leeds, and York; and on ye other by Chichester, Gravesend, and Harwich.

At London we Compute the Middle to fall at 13 min: past 9 in ye Morning, when 'tis dubious whether it will be a Total Eclipse or no, London being so near the Southern limit. The first beginning will be there at 7 min: past Eight, and ye end at 24 min: past Ten. The Oval figure shows ye space ye Shadow will take up at ye Time of ye Middle at London; And its Center will pass on to ye Eastwards, with a Velocity of nearly 30 Geographical Miles in a min: of Time.

NB. The curious are desired to Observe it, and especially the duration of Total Darkness, with all the care they can; for thereby the Situation and dimensions of the Shadow will be nicely determin'd; and by means thereof, we may be enabled to Predict the like Appearances for ye future, to a greater degree of certainty than can be pretended to at present, for want of such Observations.

By their humble Servant Edmund Halley"

The engraver, John Senex, is credited at the bottom of the map. Further credits are given at the bottom of the frame: "Sold by J. Senex, at the Globe in Salisbury Court, near Fleetstreet;



who makes, and sells the Newest and Correctest Maps, and Globes of 3, 9, 12, and 16 Inches Diameter, at moderate Prises. Sold also by William Taylor at the Ship in Paternoster Row. Entered in the Hall Book”

It was a print of this 1715 map, courtesy of the Royal Astronomical Society, that we reproduced in Golub and Pasachoff (1997). Cook (1998), in his excellent new biography of Halley, reproduces the third of the maps and summarizes the eclipse observations that Halley made and collected. Peter Hingley, Librarian of the RAS, informs me that the RAS has three of the four maps: the first, third, and fourth.

### The actual eclipse path of 1715

Soon the eclipse itself occurred, and the actual path was plotted on a new engraving (figure 2). (Williams [1996], in *UK Solar Eclipses from Year 1*, draws the actual path as a dotted line on the original map.) Halley discussed his own observations and those of others in the *Philosophical Transactions of the Royal Society*, vol. 29 (Pasachoff 1999). The broadside, with handwritten date of 1 Sept. 1715, was modified to read: “A Description of the Passage of the Shadow of the Moon over England as it was Observed in the late Total Eclipse of the Sun April 22d: 1715 Mane.”

The actual path was expanded some tens of kilometres to the south of the predicted path and slightly shifted in angle, and the drawn map accordingly was shifted to the north, allowing the revised map to show how the actual path included the Channel Islands of Guernsey and Alderney but not the Island of Jersey, similarly to the path for the 1999 eclipse including Alderney. The revised map also shows how the actual path included a small part of France north of Brest, in Bretagne; the earlier map did not show that part of France. A map scale is included for the first time. The northern limit of the path of totality still intercepted the west coast at the same location in Wales (which is not identified on Halley's map), but the egress from the east coast of England was about 20 miles farther south. Papers have been written to try to assess a secular change in size of the Sun from a comparison of paths measured then and more recently, but a paper of my own, written jointly with my former student Brant Nelson, in the journal *Solar Physics* indicates on the basis of our observations of the 1984 eclipse in Papua New Guinea that the uncertainties in the times of predictions are too great to allow the method to be reliably used. Morrison, Stephenson and Parkinson (1988) also did not find a measurable change in the Sun's diameter since 1715.

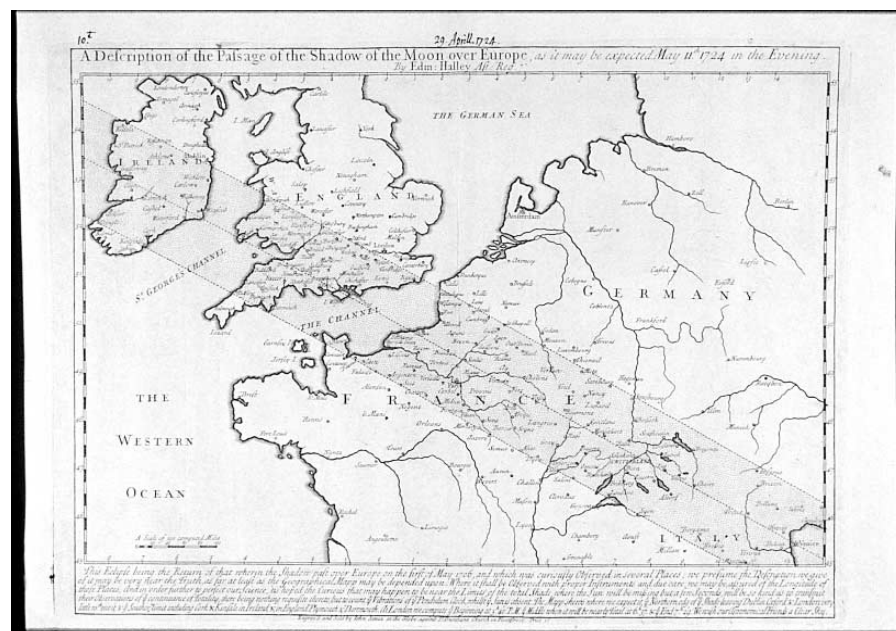
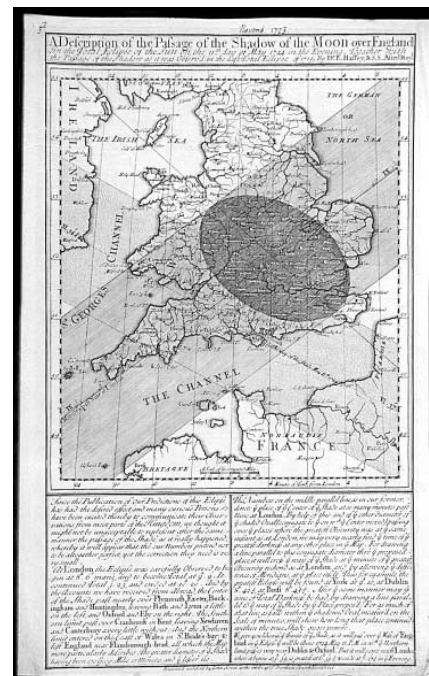
Notable on the post-eclipse 1715 map is the addition of the predicted path for the forthcoming 1724 eclipse. The new text says:

“Since the Publication of our Predictions of

this Eclipse has had the desired effect, and many curious Persons have been excited thereby to communicate their Observations from most parts of the Kingdom; we thought it might not be unacceptable to represent after the same manner the passage of the Shade, as it really happened; whereby it will appear that tho our Numbers pretend not to be altogether perfect, yet the correction they need is very small.

At London the Eclipse was carefully Observed to begin at 8h.6' mane, and to become Total at 9h.9'. It continued Total 3'.23", and ended at 10h.20'. And by the Accounts we have received from Abroad, the Center of the Shade past nearly over Plymouth, Exeter, Buckingham and Huntingdon, leaving Bath and Lynn a little on the left, and Oxford

3 (right): Halley's map of the actual path for 1715 and the predicted path for 1724, dated in hand November 1723. (With permission of the Houghton Library, Harvard University: EB7 H1552 715d2b.)



4: Halley's 1724 map of the predicted path over England and Europe, dated in hand about two weeks before the eclipse. (With permission of the Houghton Library, Harvard University: EB7 H1552 724d.)

and Ely on the right. The Southern limit past over Cranbrook in Kent, leaving Newhaven and Canterbury a very little without: And the Northern limit entered on the Coast of Wales in St. Bride's-bay, and left England near Flam-borough-head, all which ye Map more particularly describes. The greater diameter of ye Shade having been 170 Geog: Miles or Minutes, and ye lesser 110.

The Numbers on ye middle parallel line, as in our former, denote ye place of ye Center of ye Shade at so many minutes past Nine at London. By help of this and of the other diameter of the shaded Oval (conjugate to ye on[e] with ye Center moved) passing over the places where the greatest Obscurity was at ye same instant as at London, we may very nearly find

ye time of ye greatest darkness at any other place on ye Map. For drawing a line parallel to this conjugate diameter through ye proposed place, it will cross ye way of ye Shade at the minute of the greatest Obscurity reckon'd as at London, and by allowing the difference of Meridians, at ye place itself. Thus for example, the greatest Eclipse will be found at York at 9h.10, at Dublin 8h.42 1/2, at Brest 8h.43 1/2. After ye same manner may ye time of Total Darkness be had, by drawing a line parallel to ye way of ye Shade by the Place propos'd: For as much of that line as falls within ye shadowed Oval, measur'd on the Scale of minutes, will show how long that place continu'd within ye true Shade quam proxima.

We give you likewise ye Transit of ye Shade,

as it will pass over ye West of England in the Eclipse that will be Anno 1724 May 11.P.M. in which ye Northern limit passes very near Dublin & Oxford. But it will scarce reach London where it begins at 5h.39', is greatest at 6h.35 1/2', and ends at 7h.27 1/2' in the Evening."

The credit, now all outside the printed border, says: "Engraved and Sold by John Senex at the Globe in Salisbury Court near Fleetstreet."

## Preparing for the 1724 eclipse

Another copy of the same map (figure 3) is dated, in the same hand, "Novemb. 1723," and sold for only fivepence (5d). Only the heading is changed, now reading, "A Description of the Passage of the Shadow of the Moon over England In the Total Eclipse of the Sun on the 11th day of May, 1724 in the Evening. Together with the Passage of the Shadow as it was Observ'd in the last Total Eclipse of 1715. By Dr. E. Halley, R.S.S. Astro<sup>r</sup>.Roy<sup>l</sup>." Halley

Newton in his professorial chair at Cambridge, had made predictions showing the path about 40 km farther north, but the actual path went approximately midway between Halley's and Whiston's predictions. Halley had become Astronomer Royal in 1720, a post he was to hold until 1742.

The text below the map is much shorter, referring to an eclipse that had been visible over the Continent but not the British Isles. (The previous total eclipses visible from parts of England were, barely, in 1652 and, also in the west only, in 1598.) The text stated:

"This Eclipse being the Return of that wherein the Shadow past over Europe on the first of May 1706, and which was curiously Observed in several Places; we presume the Description we give of it may be very near the Truth, as far at least as the Geographical Mapp may be depended upon. Where it shall be observed with proper Instruments and due care, we may be assured of the Longitude of those Places;

The same publisher did this map from the same address: "Engrav'd and Sold by John Senex at the Globe against St. Dunstons Church in Fleetstreet. Price 1s." Since one shilling was 12 pence, perhaps our purchaser of the time got a slight discount. The price has inflated since then; a broadside of one of the 1715 maps sold in 1998 for \$15 000.

## The path of the 1999 eclipse

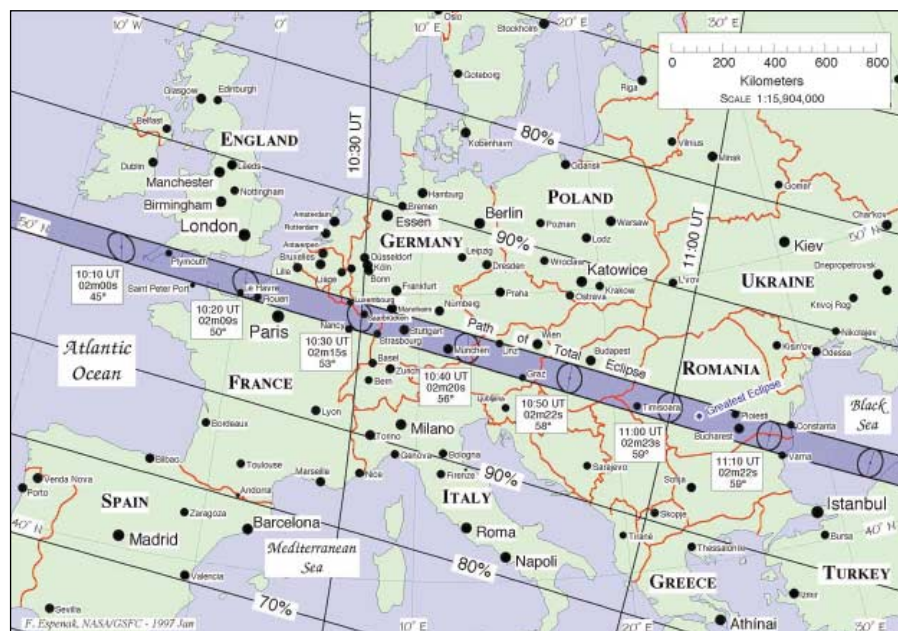
Fred Espenak's map of the 1999 total eclipse (figure 5), covering twice as great an area, is the modern counterpart to Halley's map of 284 years and three months earlier. The map is figure 3 of his NASA Reference Publication. See also Pasachoff and Covington (1993).

The sky was clear in England for observers of the 1715 eclipse, but cloudy for the 1724 eclipse. Still, for the 1999 eclipse, one can do no better than repeat Halley's statement: "We wish our Astronomical Friends a Clear Sky." ●

Jay M Pasachoff (Williams College – Hopkins Observatory, Williamstown, Massachusetts 01267, USA) is Field Memorial Professor of Astronomy and Director of the Hopkins Observatory at Williams College. He serves as Chair of the Working Group on Solar Eclipses of the IAU, and is looking forward to his 29th solar eclipse expedition in August 1999. The author wishes to thank Roger Stoddard of the Houghton Library for his assistance there. He thanks Seth Fagen of Martayan Lan, New York, for his assistance in an unsuccessful attempt to purchase one of the Halley broadsides in 1998. He is grateful to Fred Espenak for his eclipse maps. He acknowledges the support of the National Science Foundation, the Commission for Research and Exploration of the National Geographic Society, and the Solar and Heliospheric Observatory Guest Investigator Program of NASA. He thanks the Bronfman Science Center at Williams College.

## References

- Cook A 1998 *Edmond Halley: Charting the Heavens and the Seas*, Oxford University Press.
- Espenak F and Anderson J 1997 *Total Solar Eclipse of 1999 August 11* NASA Reference Publication 1398, NASA Goddard Space Flight Center, Greenbelt, Maryland.
- Gingerich O 1981, 1992 in *The Great Copernicus Chase and Other Adventures in Astronomical History* (reprinted from *Sky & Telescope* 62 324–327, 1981).
- Golub L and Pasachoff J M 1997 *The Solar Corona* CUP Cambridge, UK, p26.
- Halley E 1715 *Phil. Trans. Roy. Soc.* 29 345 245–262 & 314–316.
- Morrison L V et al. 1988 *Nature* 331 421–423
- Olson R J M and Pasachoff J M 1989 in *Comets in the Post-Halley Era* Proceedings of IAU Symposium 116 Kluwer, Dordrecht, Holland/Boston/London, p1309–1341.
- Olson R J M and Pasachoff J M 1998 *Fire in the Sky: Comets and Meteors, the Decisive Centuries*, in *British Art and Science* CUP Cambridge, UK, with the support of Gresham College, London.
- Pasachoff J M and Covington M A 1993 *The Eclipse photography Guide* CUP, Cambridge UK.
- Pasachoff J M 1999 *J. Astronomical History & Heritage*, in press.
- Pasachoff J M and Nelson B O 1987 *Solar Physics* 108 191–194.
- Williams S 1996 *UK Solar Eclipses from Year 1* Clock Tower Press, Leighton Buzzard, UK.



5: Espenak's current map of the predicted path of the total solar eclipse of 11 August 1999. (Courtesy of Fred Espenak, NASA Goddard Space Flight Center.)

was Royal Society Secretary (R.S.S.) as well as Astronomer Royal. The credit caption is also slightly different, representing only a change in location of the same publisher: "Engraved and Sold by John Senex at the Globe ag't St. Dunstons Church Fleetstreet."

The final map in the sequence (figure 4) is very different. Published, or at least dated in hand about two weeks before the eclipse, and selling for tenpence (10d), it is expanded to show the path of the eclipse over Ireland, England (with Wales again not labelled), and the Continent as far as Venice, through which the centre line of totality went. The ellipse of totality is not shown. London was just north of the path of totality. Gingerich describes how William Whiston, who had succeeded Isaac

And in order further to perfect our Science, 'tis hoped ye Curious that may happen to be near the Limits of the total Shade where the Sun will be missing but a few Seconds, will be so kind as to transmit their observations of ye continuance of Totality; there being nothing requisite thereto, but to count ye Vibrations of ye Pendulum Clock, whilst ye Sun is absent. The Mapp shows where we expect it, ye Northern edge of ye Shade leaving Dublin Oxford & London very little without it, and ye Southern limit including Cork and Kinsale in Ireland, & in England Plymouth & Dartmouth. At London we compute ye Beginning at 5.40'.P.M. ye Middle when it will be nearly Total at 6h.37'. & ye End 7h.29'. We wish our Astronomical Friends a Clear Sky."