VII. *An Account of the Extraordinary* METEOR *ſeen all over* England, *on the 19th of* March $171\frac{8}{9}$. *With a Demonſtration of the uncommon Height thereof. By* Edm. Halley, *LL. D. and Secretary to the* Royal Society.

THIS wonderful luminous *Meteor* which was ſeen in the Heavens on the 19th of *March* laſt, as it was matter of Surprize and Aſtoniſhment to the Vulgar Spectator, ſo it afforded no leſs Subject of Enquiry and Entertainment to the ſpeculative and curious in Phyſical things: Some of its *Phænomena* being exceeding hard to account for, according to the Notions hitherto received by our Naturaliſts; ſuch are the very great Height thereof above the Earth; the vaſt Quantity of the Matter thereof; the extravagant Velocity wherewith it moved; and the prodigious Exploſions thereof heard at ſo great a Diſtance, whoſe Sound, attended with a very ſenſible Tremour of the ſubject Air, was certainly propagated through a *Medium* incredibly rare and next to a *Vacuum*.

In *Num.* 341. of theſe *Tranſactions*, I have collected what I could find of ſuch-like *Meteors*, and ſince, turning over the *Ephemerides* of *Kepler*, I accidentally hit upon another, prior to all thoſe there deſcribed, and which was ſeen all over *Germany*. Of this the Words of *Kepler* are: *Die* $\frac{7}{17}$ *Nov.* 1623. *Meteorum ignitum, Globus ardens ab occaſu in ortum volans totâ paſſim* Germaniâ *fuit conſpectus. In* Auſtria *etiam fragorem exauditum affirmarunt quaſi à fulmine; quod vanum tamen puto: nihil enim tale confirmant deſcriptiones quæ extant.* Yet

neither

neither this, nor any of the other hitherto deſcribed, ſeem to come up in any Circumſtance to this late Appearance; of which I am in hopes to give a ſatisfactory Account, being enabled by the very many Relations thereof communicated to the *Royal Society*, from moſt parts of the Kingdom; tho' it was not my good Fortune to ſee it my ſelf; and tho' very few of our Countrymen who beſt know the *Stars*, had better luck. Some of the moſt perfect Deſcriptions we have receiv'd are the following:

Firſt, Our very worthy Vice-Preſident Sir *Hans Sloan*, Baronet, being abroad at that time, happen'd to have his Eyes turned towards it, in its very firſt Eruption; and the next Day he was pleaſed to give me in Writing what he had with great Exactneſs noted about it, in the Terms following: " On *Thurſday*, *March* 19. $17\frac{18}{19}$. " paſſing along Eaſtward by the N E. Corner of *Sou-* " *thampton-ſtreet* in *Bloomsbury-Square*, *London*, at about " a Quarter after Eight at Night, I was ſurpriz'd to " ſee a ſudden great Light, much beyond that of the " Moon, which ſhone then very bright. I turn'd to " the Weſtward where the Light was; which I appre- " hended at firſt to be artificial Fire-works or Rockets. " The firſt place I obſerv'd it in, was about the *Plei-* " *ades* Northerly, whence it moved after the manner, " but more ſlowly than a falling Star, in a ſeeming " direct Line, deſcending a little beyond, and withal " below, the Stars in *Orion*'s *Belt* then in the S. W. " The long Stream appear'd to me to be branched about " the middle, and the *Meteor* in its way turn'd Pear- " faſhion'd or tapering upwards. At the lower end it " came at laſt to be bigger and Spherical, tho' it was " not ſo big as the Full Moon. The Colour of it was " whitiſh, with an eye of Blue, of a moſt vivid daz- " ling Luſtre, which ſeem'd in Brightneſs very nearly

" to reſemble, if not ſurpaſs that of the Body of the " Sun in a clear Day, beheld by the naked Eye This " Brightneſs obliged me to turn my Eyes (which had " their Pupils adapted to the Light of the Moon) from " it ſeveral times, as well when it was a Stream, as " when it was Pear-faſhion'd and a Globe: tho' I had " a great Curioſity to obſerve it with Attention it " ſeem'd to move in about half a Minute or leſs, about " the Length of 20°, and to go out, as I gueſs'd, about " as much above the Horizon. There was left behind " it, where it had paſs'd, a Track of a cloudy or faint " reddiſh Yellow Colour, ſuch as red-hot Iron or glow- " ing Coals have, which remained more than a Minute, " ſeem'd to ſparkle, and kept its Place without falling. " This Track was interrupted, or had a Chaſm towards " its upper end, at about two Thirds of its Length. I " did not hear any Noiſe it made, but the place where " the Globe of Light had been, remain'd after it was " extinct, of the ſame reddiſh Yellow Colour with the " Stream for ſome time, and at firſt ſome Sparks ſeem'd " to iſſue from it, ſuch as come from red-hot Iron bea- " ten on an Anvil. The Surprize, Brightneſs of the " Light, and Noiſe of the People upon the Variations " of the Appearance, calling to one another to obſerve " what they never had obſerv'd in their Days, and " thought to be prodigious, hinder'd me from taking " notice or remembring any thing farther about it.

It were to be wiſht that Sir *Hans* had more eſpecially regarded the Situation of the Track of this Meteor among the fixt Stars, and let us know how much it paſt above the *Pleiades*, and how much under the *Belt* of *Orion*, that ſo we might with more Certainty have determin'd its Poſition in reſpect of the Horizon of *London*; for which purpoſe the whole Number of Spectators there has not furniſhed us with one ſufficient Obſerva-

Obſervation. But all the Relations, however otherwiſe differing, agree in this, that the Splendour was little inferior to that of the Sun; that within doors the *Candles* gave no manner of Light, and in the Streets not only all the *Stars* diſappear'd, but the *Moon* then Nine Days old, and high near the Meridian, the Sky being very clear, was ſo far effaced as to be ſcarce ſeen, at leaſt not to caſt a Shade, even where the Beams of the Meteor were intercepted by the Houſes: ſo that for ſome few Seconds of Time, in all reſpects it reſembled perfect Day.

The Time when this happen'd was generally reckoned at a quarter paſt Eight; but by the more accurate Account of the Rev. Mr. *Pound* (who only ſaw the Light) agreeing with what has been ſent us from the *Pariſian* Obſervatory, it appears to have been at 8^h 8′ apparent Time at *London*. And the Sun being then in $9\frac{1}{2}$ *gr.* of *Aries*, the Right Aſcenſion of the Mid-Heaven was 130 *gr.* 45′, whereby the Poſition of the Sphere of fixt Stars is given. Hence the *Lucida Pleiadum* will be found at that time to have been $25\frac{1}{4}$ *gr.* high, in an *Azimuth* 6 *gr.* to the Northward of the Weſt, and conſequently the Arch the Meteor moved in, was inclined to the Horizon with an Angle of about 27 *gr.* having its Node or Interſection therewith, nearly *South South Weſt*; as will be more evident by what follows.

At *Oxford* five Minutes earlier, Mr. *John Whiteſide*, *R. S. Soc.* Keeper of the *Aſhmole Muſeum*, and very skilful in both Mathematical and Phyſical Matters, immediately after the Extinction of the Meteor, made haſte out to ſee what it might be, and well conſider'd the Situation of the Track it had left in the Sky: He found it to have paſt about $1\frac{1}{2}$ Degree above the preceding Shoulder of *Orion*, and about $3\frac{1}{2}$ *gr.* above

the middle of his *Belt*, where there appear'd a luminous *Nubecula* of a reddiſh Light, being a Dilatation of the Track, ſeeming to have been occaſion'd by ſome Exploſion there; and by what he could learn from thoſe that ſaw it, it was thereabout that it broke out, and firſt began to efface the Stars. Hence it proceeded as to ſenſe in an Arch of a great Circle, and paſſing in the middle between the Tail of *Lepus* (θ *Bayero*) and β in the Fore-Foot of *Canis major*, it terminated about ξ in the Breaſt of the ſame, nearly in 95 *gr.* of Right-Aſcenſion, with 23 *gr.* South Declination: and at the place of its Extinction there remained a large whitiſh *Nebula*, much broader and of a ſtronger Light than the reſt of the Track, which he took for a certain Indication of a very great Exploſion made there. By Computation it will be found that the Angle this Track made with the Horizon of *Oxford* was neareſt 40 *gr.* and its Interſection due *S S W*; and that the place of its Extinction was about 9 *gr.* above the Horizon, in the Azimuth of 32 *gr.* to the *Weſt*.

At *Worceſter* Mr. *Nicolas Fatio*, a Perſon greatly skill'd in Aſtronomical Affairs, ſaw this Meteor deſcend obliquely towards the *South*, making an Angle with the Horizon of about 65°, and interſecting it about *S S W* ½ *S*, as may be collected from a Scheme thereof ſent up by him, and communicated to the *Royal Society*, ſeeming to be deſign'd with ſufficient Exactneſs. By this the Track left all *Orion* and *Canis major* to the Weſtward, and divided the Diſtance between *Sirius* and *Procyon*, ſo as to be almoſt twice as far from *Procyon* as *Sirius*. The Time here was one Minute before Eight, this City being about 9′ of Time to the Weſt of *London*, and conſequently the Right-Aſcenſion of the Mid-Heaven 128½ *gr.*

Now

Now the Situation of the three Cities *London*, *Oxford*, and *Worceſter* being nearly on the ſame *W. N. W.* Point, whereon the Track of the Meteor had its greateſt Altitude above the Horizon, equal to the Angle of its viſible Way; if we ſuppoſe it at *London* to have been 27 *gr.* high, and at the ſame time at *Worceſter* to be 65 *gr.* high, in the Plane of the Vertical Circle paſſing through *London* and *Worceſter*; ſuppoſing likewiſe the Diſtance between them to be 90 Geographical Miles, or one Degree and half of an Arch of a great Circle of the *Earth*, we ſhall by a Trigonometrical *Calculus*, too obvious to be here inſerted, find the perpendicular Height to have been 64 ſuch Miles; and the Point over which it was then perpendicular to have been 30 ſuch Miles *W. N. W.* from *Worceſter*. And the Geographical Mile to the *Engliſh* Statute Mile being as 23 to 20, this Height will be no leſs than 73 ½ *Engliſh* Miles. The place alſo directly under it, will be found to be about *Preſtain* on the Confines of *Hereford* and *Radnor*-Shires. Nor can we be much out in this Determination, the *Oxford* Obſervation concurring nearly in the ſame Concluſion.

This Altitude being added to the Semidiameter of the Earth as *Radius*, becomes the *Secant* of Eleven Degrees, ſo that the Meteor might be ſeen above the Horizon in all Places not more than 220 Leagues diſtant from it. Whence it will not be ſtrange that it ſhould be ſeen over all Parts of the Iſlands of *Great Britain* and *Ireland*, over all *Holland* and the hither Parts of *Germany*, *France* and *Spain*, at one and the ſame inſtant of Time

This ſuggeſts a very great uſe that might be made of theſe momentaneous *Phænomena*, to determine the *Geographical Longitudes* of Places. For if in any two Places two Obſervers, by help of *Pendulum Clocks* duly corrected

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by Cœleſtial Obſervation, do exactly note at what Hour, Minute and Second ſuch a Meteor as this blows up and is extinguiſht, the Difference of thoſe Times will be the Difference of Longitude of the two Places, as is well known. Nor does it require ſo much as the Uſe of a *Teleſcope*, as in the Methods hitherto put in practice for that purpoſe: ſo that if theſe Appearances could be predicted, and Notice given of their coming, that we might know when to expect them, I ſhould make no Difficulty to prefer this way of ſettling the *Geography* of a Country before all others.

Having thus fixt one Point in the Line of its Motion, let us now conſider what courſe the Meteor took from thence. And firſt at the Town of *Kirkby-Stephens*, on the Borders of *Yorkſhire* and *Weſtmoreland*, in a Meridian very little to the Weſtward of *Worceſter*, but about $2\frac{1}{2}$ *gr.* more to the North, it was obſerved to break out as from a dusky Cloud, directly under the Moon, and from thence to deſcend, nearly in a Perpendicular, almoſt to the Horizon. Now the Moon, being at that time in the third Degree of *Leo*, was about half an hour paſt the Meridian, and conſequently much about a point to the Weſt, or *S b W:* and the Situation of *Preſtain* from *Kirby-Stevens* being ſufficiently near upon the ſame Point, it follows that the Direction of the Track of the Meteor was according to the Great Circle paſſing over thoſe two Places.

And this is further confirm'd by the Obſervation of *Sam. Cruuys*, Eſq; *Reg. Soc. Soc.* who at *Tiverton*, about twelve Geographical Miles nearly due North from *Exeter*, obſerved the firſt Exploſion of this Meteor exactly in his Zenith, as he was aſſured by applying his Eye to the ſide of his Door, which he took to be perpendicular, and looking upwards: And from thence he ſaw it deſcend to the Southwards directly in the ſame

Azimuth, without declining either to the Right or Left: Hence it is plain, that the Track likewiſe paſs'd over this place, which by our beſt Maps is found to lie in a Line with *Preſtain* and *Kirby-Stevens* with ſufficient Exactneſs; ſo that we ſhall take it for granted that this was the very Courſe it held.

On this Suppoſition, that the firſt Exploſion attended with the reddiſh *Nubecula*, was directly over *Tiverton*, we have the *Oxford* Obſervation to compare with it, in order to determine more nicely the perpendicular Altitude there. At *Oxford* this *Nubecula* was found to be $3\frac{1}{2}$ *gr.* above the middle Star of *Orion*'s *Girdle*, at $8^h\ 3'$, and was therefore $26\frac{1}{2}$ *gr.* above the Horizon; and the Diſtance between *Oxford* and *Tiverton*, being 1°. 55′ or 115 Geographical Miles, it will be as the Sine of 61°. 35′ to the Sine of 63° 30′ So the Semidiameter of the Earth being $3437\frac{1}{2}$ ſuch Miles, to 3498 Miles the Diſtance of the Meteor from the Center of the Earth; from which deducting the Semidiameter, there remains $60\frac{1}{4}$ Geographical Miles for the Height of the Meteor above *Tiverton*: And that this was ſo is confirmed by the Obſervation of the Rev. Mr. *Will. Derham*, who at *Windſor* ſaw the aforeſaid *Nubecula* about two Degrees above the moſt Southerly of the Seven Stars in the Shield of *Orion*; that is (the Time being $8^h\ 6'$) in the Altitude of $23\frac{1}{2}$ *gr.* whence, the Diſtance between *Tiverton* and *Windſor* being 150 meaſured Miles, or 130 Geographical, by a like Proportion we ſhall find the ſame Height of the Meteor 60 ſuch Miles wanting only one Quarter. So that in a round Number we may conclude it to have been juſt 60 Geographic or 69 Statute Miles above the Earth's Surface. Nor is it poſſible to come at a preciſe Determination of this matter, by reaſon of the Coarſeneſs and Inaccuracy of our *Data*, which were only

only the Notes of Perſons under the Surprize of the ſuddenneſs of the Light, and no ways pretending to Exactneſs; however, ſuch as they are, they abundantly evince the Height thereof to have exceeded 60 *Engliſh* Miles, not to ſay 38 or 40, as ſome would fain have it.

I was unwilling to leave off, till I had pitcht upon ſome Hypotheſis that might ſubject the Motion of this Meteor to a *Calculus*, that the Curious might be able to compute the viſible way thereof, either in reſpect of the Horizon or among the fixt Stars: This I found might be done with tolerable Exactneſs, ſuppoſing that it mov'd in the Arch of a Circle concentrick with the Earth, but 60 Geogr. Miles without it; and that the Point of the firſt Exploſion was over the Lat. of 50° 40′ and 3° 40′ to the Weſt of *London*; and that of the laſt Extinction over Lat. 47°. 40′ with 4°. 50′ *Weſt* Longitude: The Time being fixt to 8 Minutes paſt Eight at *London*. Hence it will be eaſy, by a Trigonometrical Proceſs, to obtain the viſible Altitude and Azimuth of the Meteor at either of its Expleſions, as ſeen from any Place whoſe Longitude and Latitude is known; and from the Time given, the Points in the Sphere of Stars anſwering to thoſe Azimuths and Altitudes are readily deduced. Let thoſe that contend for a much leſs Height of this Meteor try if they can on ſuch their Suppoſition reconcile the ſeveral *Phænomena* before recited with one another, and with the Obſervation of the Rev. Mr. *William Ella*, Rector of *Eampton* in *Nottinghamſhire*, between *Gainsborough* and *Redford*, which for its Exactneſs I muſt not omit. Here at 8ʰ 5′ the Meteor was ſeen to paſs preciſely in the middle between *Sirius* and the Fore-Foot of *Canis major*, moving obliquely to the Southward, in a Line whoſe Direction ſeem'd to be from the middle between

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the two Shoulders of *Orion*. The Latitude of the place being nearly 57°. 20′, and Longitude *Weſt* from *London* 0°. 45′. Let them try how they can account for its being ſeen five Degrees high at *Aberdeen* in *Scotland*, and near as much at *Peterhead* half a Degree more Northerly: and then they will be better able to judge whether it did not exceed the reputed Limits of our Atmoſphere. Laſtly, if the apparent Altitude of the Meteor at *Paris* was not 5½ but 11 *gr.* on the *W b N* Point, when it muſt have been in its greateſt Luſtre, there will be no pretence to bring it lower than I have made it, eſpecially if it be allowed to have follow'd the Track I have aſſign'd it, over *Preſtain*, *Cardiff*, *Minhead*, *Tiverton*, and *Breſt* in *Bretany*.

Allowing this to have been the Path it mov'd in, it would be eaſy to aſſign the real Magnitude and Velocity of this Meteor, if the ſeveral Accounts of its apparent Diameter, and of the Time of its Paſſage from one of its Exploſions to the other, were conſiſtent with themſelves. But ſome of them making its viſible Appearance nearly equal to the Sun's, which in the Opinion of many it far exceeded, we may ſuppoſe with the leaſt that, at the time when it firſt broke out over *Tiverton*, its Diameter was half a Degree. And its Horizontal Diſtance being 150 Geogr. Miles from *London*, and its Altitude 60, the Hypothenuſal or real Diſtance from the Eye will be more than 160 ſuch Miles; to which Radius the Subtenſe of half a Degree will be above an Engliſh Mile and half, being about 2800 Yards *quamproximè*. After the ſame manner it is difficult to aſſign its due Velocity, whilſt ſome make it half, others leſs than a quarter, of a Minute, in paſſing from its firſt Exploſion to its laſt Extinction: But the Diſtance it moved in that time being about 3 *gr.* or 180 Geogr. Miles, we may modeſtly compute

it to have run above 300 ſuch Miles in a Minute; which is a Swiftneſs wholly incredible, and ſuch, that if a heavy Body were projected horizontally with the ſame, it would not deſcend by its Gravity to the Earth, but would rather fly off, and move round its Center in a perpetual Orb, reſembling that of the *Moon*.

Of ſeveral Accidents that were reported to have attended its Paſſage, many were the effect of pure Fancy; ſuch as the hearing it hiſs as it went along, as if it had been very near at hand: others imagined they felt the Warmth of its Beams; and ſome there were that thought, at leaſt wrote, that they were ſcalded by it. But what is certain, and no way to be diſputed, is the wonderful Noiſe that follow'd its Exploſion. All Accounts from *Devon* and *Cornwal* and the neighbouring Counties are unanimous, that there was heard there, as it were the Report of a very great Cannon, or rather of a Broad ſide, at ſome diſtance, which was ſoon follow'd by a rattling Noiſe, as if many ſmall-Arms had been promiſcuouſly diſcharged. What was peculiar to this Sound was, that it was attended with an uncommon Tremour of the Air, and every where in thoſe Counties, very ſenſibly ſhook the Glaſs-Windows and Doors in the Houſes, and according to ſome, even the Houſes themſelves, beyond the uſual Effect of Cannon, though near; and Mr. *Crurys* at *Tiverton*, on this occaſion, loſt a Looking-Glaſs, that being looſe in its Frame, fell out on the ſhock, and was broken. Nor do we yet know the Extent of this prodigious Sound, which was heard, againſt the then Eaſterly Wind, in the Neighbourhood of *London*, as I am inform'd; and by the Learned Dr. *Tabor*, who diſtinctly heard it beyond *Lewis* in *Suſſex*: So that I cannot help thinking, that ſuch a Meteor as this might have occaſion'd that famous Ode of *Horace*: *Parcus Deorum cultor*, &c.

* ——— *Namque*

——— *Namque Dieſpiter*
Igne coruſco nubila dividens
Plerumque, per purum tonantes
Egit equos volucremque currum,
Quo bruta tellus, &c. Concutitur. ———

But whether the Report heard near *Lewis* were of that Exploſion right over *Devonſhire*, or rather of that latter and much greater at the Extinction over *Britany*, I ſhall not undertake to determine, till we have ſome further Accounts from *France*, whence hitherto we have only had, that at *Paris* the Time of the Appearance was at 17 Minutes paſt Eight.

It remains to attempt ſomething towards a Solution of the uncommon *Phænomena* of this Meteor; and by comparing them with things more familiar to us, to ſhew at leaſt how they might poſſibly be effected. And firſt the unuſual and continu'd Heats of the laſt Summer in theſe Parts of the World, may well be ſuppos'd to have excited an extraordinary Quantity of Vapour of all ſorts; of which the aqueous and moſt others, ſoon condens'd by Cold, and wanting a certain Degree of Specifick Gravity in the Air to buoy them up, aſcend but to a ſmall Height, and are quickly returned in Rain, Dews, *&c.* whereas the inflammable ſulphureous Vapours, by an innate Levity, have a ſort of *Vis centrifuga*, and not only have no need of the Air to ſupport them, but being agitated by Heat, will aſcend in *Vacuo Boileano*, and ſublime to the top of the Receiver, when moſt other Fumes fall inſtantly down, and lie like Water at the bottom; the Experiment whereof was firſt ſhewn me by the Reverend Mr. *Whiteſide* at *Oxford*, and was very lately made before the *Royal Society*. By this we may comprehend how the matter of the Meteor might have been raiſed from a large Tract of the Earth's Surface, and aſcend far above the reputed Limits of the *Atmoſphere*; where, being diſengaged from all other Particles, by that principle of Nature that congregates *Homogenia* viſible in ſo many Inſtances, its Atoms

Atoms might in length of time coaleſce and run * *fortuitouſly* together, as we ſee Salts ſhoot in Water; and gradually contracting themſelves into a narrower compaſs, might lie like a Train of *Gunpowder* in the *Ether*, till catching fire by ſome internal Ferment, as we find the Damps in Mines frequently do, the Flame would be communicated to its continued parts, and ſo run on like a Train fir'd.

This may explain how it came to move with ſo unconceivable a Velocity; for if a continu'd Train of Powder were no bigger than a Barrel, it is not eaſy to ſay how very faſt the Fire would fly alongſt it; much leſs can we imagin the Rapidity of the Accenſion of theſe more inflammable Vapours, lying in a Train of ſo vaſt a Thickneſs. If this were the Caſe, as it is highly probable, it was not a Globe of Fire that ran along, but a ſucceſſive kindling of new Matter: and as ſome parts of the Earth might emit theſe Vapours more copiouſly than others, this Train might in ſome parts thereof, be much denſer and bigger than in others, which might occaſion ſeveral ſmaller Exploſions, as the Fire ran along it, beſides the great ones which were like the blowing up of Magazines. Thus we may account for the rattling Noiſe like ſmall-Arms, heard after the great Bounce on the Exploſion over *Tiverton*; the Continuance of which for ſome time, argues that the Sound thereof came from Diſtances that encreaſed.

What may be ſaid to the Propagation of the Sound thro' a *Medium*, according to the receiv'd Theory of the Air above 300000 times rarer than what we breath, and as I ſaid before, next to a *Vacuum*, I muſt confeſs I know not. Hitherto we have concluded the Air to be the Vehicle of Sound; and in our artificial *Vacuum* we find it greatly diminiſh'd: but we have this only Inſtance of the effect of an Exploſion of a Mile or two diameter, the immenſity of which may perhaps compenſate the extream Fineneſs of the *Medium*.

F I N I S.

* Dele *fortuitouſly*.