

For which, this consideration of the *Common Center of Gravity of the Earth and Moon*, is so proper a remedy (especially if it shall be found precisely to answer those *Phænomena*, which I have not Examined, but am very apt to believe) that it is so far from being, with me, an Objection against it, that it is one of the reasons, which make me inclinable to introduce it.

I must before I leave this, add one Consideration more, That if we shall upon these Considerations think it reasonable, thus to consider the *Common Center of Gravity of the Earth and Moon*; it may as well be thought reasonable, that the like Consideration should be had of *Jupiter* and his four *Satellites*, which according to the Complication of their several motions, will somewhat change the position of *Jupiter*, as to that *Common center of Gravity* of all these Bodies; which yet, because of their smallness, may chance to be so little, as that, at this distance, the change of this apparent place may not be discernable. And what is said of *Jupiter*, is in the like manner to be understood of *Saturne* and his *Satelles*, discovered by *Hugenius*: For all these *Satellites* are to their *Principals*, as so many Moons to the Earth. And I do very well remember, in the Letters forecited, Mr. *Horrocks* expresseth some such little inequalities in *Saturnes* motion, of which he could not imagine what account to give, as if (to use his Expression) this crabbed *Old Saturn* had despised his *Youth*. Which, for ought I know, might well enough have been accounted for, if at that time the *Satelles* of *Saturn* had been discovered, and that Mr. *Horrocks* had thought of such a motion as the *Common Center of Gravity* of *Saturn* and his *Companion*, to be considerable, as to the guiding of his motion.

You have now, in obedience to your Commands, an Account of my thoughts, as to this matter, though yet immature and unpolished: What use you will please to make of them, I shall leave to your prudence, &c.

*An APPENDIX, written by way of Letter to the Publisher; Being an Answer to some Objections, made by several Persons, to the precedent Discourse.*

I Received yours; and am very well contented, that objections be made against my *Hypothesis* concerning *Tydes*: being

proposed but as a conjecture to be examined; and, upon that Examination, rectified, if there be occasion; or rejected, if it will not hold water.

1. To the first objection of those you mention; *That it appears not how two Bodies, that have no tye, can have one common Center of Gravity*: that is (for so I understand the intendment of the objection) can act or be acted in the same manner, as if they were connected: I shall onely answer, that it is harder to shew *How* they have, than *That* they have it. That the Load-stone and Iron have somewhat equivalent to a Tye; though we see it not, yet by the effects we know. And it would be easy to shew, that two Load-stones, at once applied, in different positions, to the same Needle, at some convenient distance; will draw it, not to point directly to either of them, but to some point between both; which point is, as to those two, the *common Center of Attraction*; and it is the same, as if some *one* Load-stone were in that point. Yet have these two Load stones no connexion or tye, though a *Common Center of Virtue* according to which they joyntly act. And as to the present case, *How* the Earth and Moon are connected; I will not now undertake to shew (nor is it necessary to my purpose;) but, That there is somewhat, that doth connect them, (as much as what connects the Load-stone, and the Iron, which it draws,) is past doubt to those, who allow them to be carried about by the Sun, as one Aggregate or Body, whose parts keep a respective position to one another: Like as *Jupiter* with his *four Satellites*, and *Saturn* with his *one*. Some Tye there is, that makes those *Satellites* attend their *Lords*, and move in a Body; though we do not *See* that Tye, nor *Hear* the Words of Command. And so here.

2. To the second objection; *That, at Chatham and in the Thames, the Annual Spring-tydes, happen about the Æquinoxes; not (as this Hypothesis doth suppose elsewhere to have been observed) about the beginning of February and November.* If their meaning be, that Annual High Tydes, do then happen, and then onely: If this prove true, it will ease me of half my work. For it is then easily answered, that it depends upon the *Obliquity of the Zodiack*; the parts of the *Æquinoctial* answering to equal parts of the  
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*Zodiack*, being near the Solstitial points greatest, and near the *Æquinoctial* points least of all. But beside this *Annual Vicissitude of the Æquinoxes*, not to say, of the 4. Cardinal Points (which my Hypothesis doth allow and assert;) I believe it will be found, that there is another *Annual vicissitude* answering to the Suns *Apogæum* and *Perigæum*. And that the greatest Tydes of all, will be found to be upon a result of these two causes Co-operating: which (as doth the Inequality of Natural dayes, depending on these same causes) will light nearer the times, I mention. To what is said to be observed at *Chatham* and in the *Thames*, contrary to that I allege as observed in *Rumney marsh*: I must at present ἀπέχεσθαι, and refer to a *melius inquirendum*. If those who object this contrary observation, shall, after this notice, find, upon new Observations heedfully taken, that the *Spring-tydes* in *February* and *November*, are not so high, as those in *March* and *September*; I shall then think the objection very considerable. But I do very well remember, that I have seen in *November*, very high Tydes: at *London*, as well as in *Rumney Marsh*. And, the time is not yet so far past, but that it may be remembered (by your self or others then in *London*) whether in *November* last when the Tydes were so high at *Dover*, at *Deal*, at *Margate*, and all along the Coast from thence to *Rumney Marsh*, as to do in some of those places much hurt, (and; in *Holland*, much more;) whether, I say, there were not also at the same time, at *London*, (upon the *Thames*) very high Tydes. But a good *Diary* of the Height and time both of High-water, and Low-water, for a year or two together, even at *Chatham*, or *Greenwich*; but rather at some place in the open Sea, or at the *Lands end* in *Cornwal*, or on the *West parts of Ireland*; or at *St. Hellens*, or the *Bermudas*, &c. would do more to the resolving of this point, than any verbal discourse without it.

3. To the third Objection, *That supposing the Earth and Moon to move about a Common center of gravity; if that the highest Tydes be at the New-moon, when the moon being nearest to the Sun, the Earth is farthest from it, and its compound motion at the swiftest; and that the Tydes abate as the Earth approacheth nearer, till it comes into the supposed Circle of her Annual motion: It may be demanded; why do they not still abate as the Earth comes yet nearer to the Sun and the*  
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swiftnesse of its compound motion still slackens? And so, why have we not Spring tides at the New Moon (when the motion is swiftest) and Neap-tides at Full Moon (when the motion is slowest) but Spring tides at both? The answer (if observed) is already given in my Hypothesis it self. Because the effect is indifferently to follow, either upon a suddain Acceleration, or a suddain Retardation. ( Like as a loose thing, lying on a moving body; if the body be thrust suddainly forward, that loose thing is cast back, or rather left behind, not having yet obtained an equal *impetus* with that of the body, on which it lyes; but if stopped, or notably retarded, that loose incumbent is thrown forward, by its formerly contracted *impetus* not yet qualified or accomodated to the slowness of the Body, on which it lyes. ) Now both of these happening, the one at the New Moon, the other at the Full Moon, do cause high Tides at both.

4. To the fourth Objection, *That the highest Tydes are not at all places, about the New Moon and Full Moon; and particularly, that, in some places of the East Indies, the Highest Tydes are at the Quadratures*: I must first answer in *general*; That as to the particular varieties of Tydes in several parts of the World, I cannot pretend to give a satisfactory account, for want of a competent History of Tydes, &c. Because (as is intimated in what I wrote in the *general*) the various positions of Channels, Bays, Promontories, Gulfs, Shallows, Currents, Trade-winds, &c. must needs make an innumerable variety of Accidents in particular places, of which no satisfactory account is to be given from the general Hypothesis (though never so true) without a due consideration of all those. Which is a task too great for me to undertake, being so ill furnished with materials for it. And then as to the particular instance of some places in the *East Indies*, where the highest Tydes are at the *Quadratures*: I suppose, it may be chiefly intended of those about *Cambaia*, and *Pegu*. At which places, beside that they are situate at the inmost parts of Vast Bayes, or Gulfs (as they are called) they have also vast In-draughts of some hundred Miles within Land; which when the Tydes are out, do lye (in a manner) quite dry: And may therefore very well be supposed to participate the effect of the Menstrual Tydes many dayes after the  
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cause of them happens in the open Sea, upon a like ground as in Straights and narrow Channels the Diurnall Tydes happen some hours later than in the Ocean. And a like account must be given of particular accidents in other places, from the particular situation of those places, as *Bays, Channels, Currents, &c.*

5. To the 5. Objection, *That the Spring-Tydes happen not, with us, just at the Full and Change, but two or three daies after.* I should with the more confidence attempt an Answer, were I certain, whether it be so in the *Open Seas*, or onely in our Channels. For the Answers will not be the same in both cases. If onely in our Channels, where the Tydes find a large in-draught; but not in the *Open Seas*: we must seek the reason of it from the particular position of these places. But if it be so generally in the wide *Open Seas*: We must then seek a reason of it from the general Hypothesis. And, till I know the matter of Fact, I know not well, which to offer at; left whilst I attempt to salve one, I should fall foul of the other. I know that Mariners use to speak of Spring-Tydes at the New and Full of the Moon; though I have still had a suspicion that it might be some daies after, as well in the open Seas; as in our narrower Channels; (and therefore I have chosen to say, in my Papers, *About* the New and Full, rather than *At* the New and Full; and even when I do say *At*, I intend it in that laxer sense in which I suppose the Marriners are to be understood; for *Neer* that time:) Of which suspicion you will find some intimations even in my first Papers: But this though I can admit; yet, because I was not sure of it, I durst not build upon it. The truth is, the Flux and Reflux of water in a vessel, by reason of the jogging of it; though it follow thereupon; yet is, for the most part, discernable some time after. For there must, upon that jog, be some time for Motion, before the Accumulation can have made a Tyde. And so I do not know but that we must allow it in all the Periods. For as the *menstrual* High Tyde, is not (at least with us) till some Daies after the Full and Change; so is the *Diurnal* High water, about as many Hours after the Moons comming to South; (I mean, *At Sea*: for in Channels it varies to all Hours, according as they are neerer or further from the open Sea:) And the *Annual* High-Tydes of *November* and *February*; somewhat later than  
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(what I conjecture to be from the same causes) the greatest Inequalities of the natural Days, happening in *January* and *October*. But this though I can admit, yet (till I am sure of the matter of Fact) I do not build upon. And since it hath hitherto been the custome to speak with that laxness of expression; assigning the times of New-moon, Full-moon, and Quadratures, with the Moons coming to South, for, what is near those times: I did not think my self obliged in my conjectural Hypothesis (while it is yet but a *Candidate*) to speak more nicely. If the Hypothesis for the maine of it be found Rational; the Niceties of it are to be adjusted, in time, from particular Observation.

Having thus given you some Answers to the Objections you signifie to have been made by several persons to my Hypothesis, and that in the same order your Paper presents them to me: I shall next give you some account of the two *Books*, which you advised me to consult; so far as seems necessary to this business: Which, upon your intimation, I have since perused, though before I had not.

And first, as to that of *Isaac Vossius*, *De motu Marium & Venerum*; Though I do not concur with him in his Hypothesis; That all the *Great motions of the Seas*, &c. should arise onely from *so small a warming of the water* as to raise it (where most of all) *not a Foot* in perpendicular, (as in his *12th* Chapter;) Or that there is no other connexion between the Moons motion, and the *Tydes menstrual* period, than a *casual Synchronism* (which seems to be the doctrine of his *16th* and *18th* Chapters;) Beside many other things in his Philosophy, which I cannot allow: Yet I am well enough pleased with what is Historical in it, of the matter of Fact: Especially if I may be secure, that he is therein accurate and candid, not wresting the *Phænomena* to his own purpose. But I find nothing in it, which doth induce me to vary from my Hypothesis. For, granting his Historicals to be all true; the account of the constant Current of the Sea Westward, and of the constant Eastern Blasts, &c. within the *Tropicks*, is much more plausibly, and (I suppose) truly rendered by *Galilæo* long since, from the Earths *Diurnal* motion: (which, neare the *Æquator*. describing a greater Circle, than nearer the *Poles*,

*Poles*, makes the Current to be there more conspicuous and swift, and, consequently, the Eddy, or recurrent motion, nearer the Poles, where this is, more remis: ) than can easily be rendered by so small a Tumor, as he supposeth. Not to adde; that his account of the Progressive motion, which he fantasieth to follow upon this Tumefaction, and by Acceleration to grow to so great a height near the Shoar ( as in Chap. 13. and 14. ) is a Notion, which seems to me too extravagant to be salved by any laws of *Staticks*. And that of the Moons motion onely Synchronizing with the Tydes, casually, without any *Physical* connexion; I can very hardly assent to. For it can hardly be imagined, that any such constant *Synchronisme* should be in Nature; but where, either the one is the cause of the other, or both depend upon some *Common* cause. And where we see so fair a foundation for a *Physical* connection. I am not prone to ascribe it to an Independent Synchronism. In sum; His History doth well enough agree with my Hypothesis; and I think, the Phænomena are much better salved by mine, than his.

And then as to *Gassendus*, in his discourse *De Æstu Maris*; I find him, after the relating of many other Opinions concerning the Cause of it, inclining to that of *Galilæo*, ascribing it to the Acceleration & Retardation of the Earths motion, compounded of the Annual and Diurnal; And moreover attempting to give an account of the *Menstrual Periods* from the Earths carrying the Moon about it self, as *Jupiter* doth his *Satellites*; which together with them is carryed about by the *Sun*, as one Aggregate; (and that the Earth with its Moon is to be supposed in like manner to be carried about by the Sun, as one Aggregate, cannot be reasonably doubted, by those who entertain the *Copernican Hypothesis*, and do allow the same of *Jupiter* and his *Satellites*.) But though he would thus have the Earth and Moon looked upon as two parts of the same moved Aggregate, yet he doth still suppose ( as *Galilæo* had done before him ) that the line of the Mean Motion of this Aggregate ( or, as he calls, *motus æqualis et veluti medius* ) is described by the Center of the *Earth* ( about which Center he supposeth both its own revolution to be made, and an Epicycle described by the Moons motion; ) not by another Point, distinct from the Centers of both, about which, as the

common Center of Gravity, as well that of the Earth, as that of the Moon, are to describe several Epicycles. And, for that Reason fails of giving any clear account of this *Menstrual* Period. (And in like manner, he proposeth the Consideration as well of the Earths *Aphelium* and *Peribelum*, as of the *Æquinoctial* and *Solstitial* Points, in order to the finding a Reason of the *Annual Vicissitudes*; but doth not fix upon any thing, in which himself can Acquiesce: And therefore leaves it *in medio* as he found it.)

It had been more agreeable to the Laws of *Statics*, if he had, (as I do,) so considered the *Earth* and *Moon* as two parts of the same movable, (not so, as he doth, *aliam in Centro et sequentem præcise revolutionem axis, aliam remotius ac velut in circumferentia*, but,) so, as to make neither of them the Center, but both out of it, describing Epicycles about it: Like as, when a long stick thrown in the Air, whose one end is heavier than the other, is whirled about, so as that the End, which did first fly foremost, becomes hindmost; the proper line of motion of this whole Body is not that, which is described by either End, but that, which is described by a middle point between them; about which point each end, in whirling, describes an Epicycle. And indeed, in the present case, it is not the Epicycle described by the Moon, but that, described by the Earth, which gives the *Menstrual* Vicissitudes of motion to the Water; which would, as to this, be the same, if the Earth so move, whether there were any Moon to move or not; nor would the Moons Motion, supposing the Earth to hold on its own course, any whit concern the motion of the Water.

But now, (after all our Physical, or Statical Considerations) the clearest Evidence for this Hypothesis (if it can be had) will be from Celestial Observations. As for instance; (see *Fig. 5.*) Supposing the Sun at S; the Earths place in its Annual Orb at T; and *Mars* (in opposition to the Sun, or near it) at M: From whence *Mars* should appear in the Zodiack at  $\gamma$ , and will at Full moon be seen there to be; the Moon being at C and the Earth at c: (and the like at the New-moon.) But if the Moon be in the First quarter at A, and the Earth at a; *Mars* will be seen, not at  $\gamma$ , but at  $\alpha$ ; too slow: And when the Moon is at B; and the Earth at b. *Mars* will be seen at  $\beta$ ; yet too slow: till at the Full-moon,



moon, the Moon at C, the Earth at c, *Mars* will be seen at  $\gamma$ , its true place, as if the Earth were at T. But then, after the Full, the Moon at D, the Earth at d; *Mars* will be seen, not at  $\gamma$ , but at  $\delta$ ; too forward: and yet more, when the Moon (at the last Quarter) is at E, the Earth at e, and *Mars* seen at  $\epsilon$ . If therefore *Mars* (when in opposition to the Sun) be found (all other allowances being made) somewhat too backward before the Full moon, and somewhat too forward after the Full-moon, (and most of all, at the Quadratures: ) it will be the best confirmation of the Hypothesis. (The like may be fitted to *Mars* in other positions, *mutatis mutandis*; and so for the other Planets.)

But this proof, is of like nature as that of the Parallax of the Earths Annual Orb to prove the Copernican Hypothesis. If it can be observed, it proves the Affirmative; but if it cannot be observed, it doth not convince the Negative, but only proves that the Semidiameter of the Earths Epicycle is so small as not to make any discernable Parallax. And indeed, I doubt, that will be the issue. For the Semidiameter of this Epicycle, being little more than the Semidiameter of the Earth it self, or about  $1\frac{1}{2}$  thereof (as is conjectured, in the *Hypothesis*, from the Magnitudes and Distances of the Earth and Moon compared;) and there having not as yet been observed any discernable *Parallax* of *Mars*, even in his nearest position to the Earth; it is very suspicious, that here it may prove so too. And whether any of the other Planets will be more favourable in this point, I cannot say.

### ANIMADVERSIONS

Of Dr. Wallis, upon Mr. Hobs's late Book, De Principiis & Ratiocinatione Geometrarum.

These were communicated by way of Letter, written in Oxford, July 24. 1666. to an Acquaintance of the Author, as follows:

Since I saw you last, I have read over Mr. Hobs's Book *Contra Geometras* (or *De Principiis & Ratiocinatione Geometrarum*), which you then shewed me. A New Book of Old master: Containing but a *Repetition* of what he had before told us, more than once; and which hath been Answered long agoe.

In which, though there be Faults enough to offer ample mat-