

Telesio and the Renaissance Debates on Sea Tides

Pietro Daniel Omodeo

In the concluding sections of the naturalistic treatise *De mari* (On the Sea), Bernardino Telesio outlines an explanation of the tides, consistent with the general plan of his natural philosophy *iuxta propria principia*. In the same pages he distances himself from well-established explanations based on the remote action of the Sun and Moon. His criticism is part of a historical-scientific trend toward a physical explanation of the phenomenon that excludes common astrological accounts. In this chapter, I will provide the essentials for an understanding of Telesio's speculations within a process of empirical-rational emancipation that ideally links Pico's criticism of the belief in astral influences with the Copernican-mechanical explanation of the tides by Galileo in his *Dialogo sopra i massimi sistemi del mondo*.

1. Telesio's explanation of the tides

Telesio first deals with sea tides, the topic of the so-called *fluxus et refluxus maris*, in Chapter x of *De mari*, "Motum mari necessarium fuisse et a quibus intumescit moveturque" (The motion of the sea was necessary, and by what things it is moved and raised). According to Telesio, the general cause of the continuous motion of the sea is its simmering, produced by solar heat and the formation of vapours "which attempt to come out but are hindered in this attempt by the sea above; as a consequence they raise and swell it just like the spirit that fire generates in the water."¹ Hence the waves are analogous to the boiling of water in a pot.

[...] and so one sees the alternating flow and ebb of the sea, mostly in equal time intervals of six hours. The reason for that is that during this time interval so many vapours are generated in the sea capable of raising and pushing it for that time. However, the rapidity of the sea seems marvellous

¹ Bernardino Telesio, *De mari*, in *De iis que in aere fiunt et de terremotibus / De mari. Con traduzione italiana a fronte di Francesco Martelli*, a cura di Luigi Franco, Cosenza: Bios, 1990, p. 113: "li quali sforzandosi di uscire et essendo prohibiti di farlo dal mare sopraposto, a guisa di spirito generato nell'acqua dal foco, lo innalzano e lo fanno gonfiare."

in narrow and hollow places. In fact, in an open space nothing forces it [the sea water] to accelerate its motion if it is pushed by the sea behind. If it [the sea water] goes through narrow places it cannot pass all at once but only in part; as [this portion of the flowing sea water] hinders the flow of the [water] behind and hence is pushed and spurred, it accelerates its motion by necessity [...].²

The tides are thus a marine simmering, which must be related to the flow of currents in the straits. Telesio advances the idea of a circular motion of the waters toward the west observed not only in the Mediterranean but also in regard to ships crossing the oceans. The Spanish navigators employ 24 days to reach the New World but a full three months to return, “as they are hindered by the opposite waters, flowing in the opposite direction.”³ Similarly the Portuguese navigators are hindered by the flow of water in their journeys to the East Indies beyond the Cape of Good Hope but are aided during the return voyage for the same reason.

In Chapters xi and xii of *De mari*, Telesio discusses and refutes the theories of those who believe that the phenomenon of the tides results from the remote action of the Sun or Moon. Some conceive such action as an influence (*influxus quidam a Luna in mare missus*), others as a magnetic action (*quomodo ferrum ad magnetem*). The main difficulty of these explanations is in assuming the possibility of long-distance actions without intermediate causes, which we could call ‘arcane’ or ‘occult’. Telesio puts the reader on guard against those who assume that there is an “incorporeal faculty emitted by the Moon” (*incorporea facultas a Luna emissa*).

One should not listen to them just as [one should not listen to] those who assert that the Moon emanates an incorporeal faculty (something that is impossible to understand to the human intellect) which raises and moves the whole sea with so great and many motions without moving any other being, even if there is earth between it and the Moon.⁴

² Ibid., p. 115: “[...] e così si vede, come per vicenda, il flusso e reflusso del mare, et il più delle volte in tempo eguale, e l’uno e l’altro in spatio di sei hore; e questo per che in quello spatio di tempo si generono nel mare tanti vappori, che per quel tempo lo possono inalzare e spignere; ma ne’ luoghi stretti e ne’ cavati apparisce maravigliosa la celerità del mare, per che scorrendo egli per loco aperto e non essendo dal mare anteriore sospinto, non ha cosa che lo stimoli a concitare il moto; ma passando per lochi stretti non può correre tutto insieme, ma solamente una piccola parte, e quel che rimane dando impedimento al corso di quello che li vien dretto, e per ciò essendo sospinto e stimolato, è necessario che egli acceleri il moto [...]”

³ Ibid., p. 117: “repugnando loro le acque contrarie, in contraria parte correnti.”

⁴ Ibid., p. 123: “[Costoro] non dovrebbero essere ascoltati come quelli che vogliono che la Luna emetta una facultà incorporea (cosa che non è possibile comprendere con l’intelletto umano) la quale senza muovere le altre acque ed alcun altro ente [...], innalzerebbe e muoverebbe con così grandi e numerosi moti tutto il mare, persino quello al quale la terra stessa s’inframmezza tra esso e la Luna.”

In Chapter xiii, Telesio provides an explanation of the tides, particularly of the variability of their amplitude at different locations. The variations depend on the different water depths and meteorological, climatic and seasonal variations, which result in the solar heat not always being the same. The Moon in opposition would produce a greater simmering of the seas. In other words, Telesio does not deny that the Sun and Moon should be taken into account in tidal theory, but he ‘rationalizes’ their action in terms of a heating by the rays of the Sun and their propagation by the Moon’s reflection of sunlight. Nor is the basic periodicity of six hours questioned but it is not linked to the diurnal cycle and the position of the Moon. Rather it is considered a natural cycle of the waters, in which the flow is followed by an ebb aimed at restoring the original condition.

It seems that Telesio was not completely satisfied with his own theory, so much so that he deleted the last three chapters of *De mari* from the Neapolitan edition of the naturalistic *opuscula* of 1570. These sections only appeared in the posthumous Venetian edition edited by his pupil Antonio Persio in 1590.⁵

Let us summarize the main points of Telesio’s tidal theory. First the phenomenon is inserted in the more general topic of the motion of the waters. This fits within the Aristotelian-Scholastic discussion of the natural motions of the elements, especially connected with the reception and comment of *De coelo* and *Meteorologica*. Instead of a ‘natural motion’ (*motus naturalis*), Telesio considers the motions of the waters to be processes of boiling dependent on the action of the Sun. He also believes that the overall motion of the seas is a circular flow toward the west, a hypothesis supported by the ocean voyages of the Spanish and Portuguese seamen. The tides have a periodicity of six hours although their amplitude varies according to a number of local climatic, meteorological and geographical conditions. For example the presence of straits or the conformation of the coasts facilitates or hinders the marine flows. Hence Telesio’s explanation is in contrast to the theories of those who assume that the origin of the tides is a remote action without intermediate causes. In this sense, Telesio’s theoretical attempt is part of a process of ‘mechanization’ or at least of anti-astrological physical explanations since it excludes factors operating at a distance. All of these aspects must be considered in detail with reference to the wide-ranging Renaissance debate on sea tides and maritime flows.

2. *The tides as an astrological subject: Albumasar’s legacy*

⁵ Cf. Luigi De Franco, “Nota introduttiva” to Bernardino Telesio, *De iis quae in aere fiunt et de terremotibus; De mari* (Cosenza: Editoriale Bios, 1990): pp. 9-16.

It should be stressed that in the late Middle Ages and Renaissance the subject of the tides had a clear astrological connotation. Indeed a reference source in this regard was one of the most widespread texts dedicated to astrology, Albumasar's *Introductorium in astronomiam* (Introduction to Astronomy). "One can say that it is from this book – wrote Pierre Duhem – that all the [scholars of the] Latin Middle Ages learned the laws of the flow and ebb of the sea."⁶ For the famous 9th-century Persian astrologer, the phenomenon of the tides is clear and incontrovertible proof of the influence of the stars on terrestrial events. The action of the Moon on the waters is second in magnitude and visibility only to seasonal effects determined by the Sun, by its annual journey along the zodiac and by its variations in declination. In other words, in the *Introductorium* the consideration of the tides is functional to an astrological interpretation of sublunar events.⁷

Albumasar makes a careful examination of the subject in the third book of the treatise, from the fourth to the eighth chapter. The Moon's influence on the seas is introduced as a special relationship of this celestial body with their element. The Sun has a particular influence on two of the four natural elements of Aristotelian tradition: fire and air; the Moon affects the remaining two: earth and water. The explanation of the tides is based on a triad of causes: the conformation of the locality (depth, length and breadth), the particular condition (*habitus*) of the water (agitated or not because it is brought by rivers or is near sources, the density, salinity and mixture of vapours) and lunar motion.⁸

The Moon's influence is the basis of the fundamental regularity of the tides, whose variability is linked to several factors, not least the latitude of the seas subject to the lunar action. The Moon attracts the waters through a particular force, which acts by affinity or sympathy. In Latin this is called a *cognata virtus* (force of affinity), a type of astrological consonance acting without intermediate causes. The docility of the waters, induced to follow the lunar motion, is indicated as a "spontaneous inclination to be pulled" (*spontaneitas ad*

⁶ Duhem, *Le Système du Monde: Histoire des Doctrines Cosmologiques de Platon à Copernic*, vol. 2, 369: "C'est dans ce livre, peut-on dire que tout le Moyen Age latin a appris les lois du flux et du reflux de la mer. La doctrine d'Albumasar mérite donc que nous y arrêtions avec quelque complaisance."

⁷ Albumasar, *Introductorium in astronomiam* ([Venezia]: Per Jacobum pentium Leucenses, 1506), ff. a3r-v.

⁸ *Ibid.*, c1v: "Dicimus igitur quod nunquam huiusmodi accessus et recessus nisi trium rerum conventu gignitur, loci videlicet natura, aquarum habitudinem [sic!], [et] motu <Lunae>. [1.] Loci natura est ut aquarum locus profundus, longus et latus vix temporis impendio transfretandis montuosus asper et durus qualevis quolibet motu acriter repercussus multe unde tumidos fluctus concipiant. [2.] Aquarum habitudo est tantas in huiusmodi loco longo ex temperie aquas esse confusas ut nec in fluxu fluminum nec ex collatione fontium auferve minui sentiatur. Que quanto ipse condensate salebre calefacte densos vapores agent qui terre vaporibus permixti agitandis undis aspirant. [3.] Motus autem <Lunae> desuper orientis atque occidentis sepius repetitus cognata virtute eiusmodi aquas trahit: quem tractum sponte sequens quousque illa accedit: accedunt usque adeo quoad diffusius efervescentes loco suo minus contempte extremis inundant littoribus."

tractionem). The rise of the waters, as Albumasar explains, is primary and depends directly on this astrological traction. The ebb is instead secondary, being a movement aimed only at restoring the original condition prior to the external action of the Moon.⁹ Moreover, the former tendency is a kind of boiling and thus is warmer than the latter: “The flow [*accessus*] is a warming of the water and the ebb [*recessus*] a cooling down. In fact, during the flow it boils from the profoundest abyss; during the ebb the [water that] overflowed becomes colder.”¹⁰ Note that this idea is also used by Telesio in his explanation of the waves but in a completely different natural-philosophical framework. One could say that he does not reject the observation and description of the phenomenon but seeks a physical cause in opposition to the astrological one.

In the seventh chapter of the third book of the *Introductorium*, Albumasar also addresses the opinions of critics of the Moon’s remote action as the cause of the tides. In other words, he deals with those who deny one of his main arguments in favour of the astral influence and of astrology. According to them, the cause of the tides is tendencies intrinsic to the waves, thus the tides are reduced to a wave phenomenon. Albumasar’s refutation is based on several considerations. Firstly, if the tides were determined by the *nature* of the waters, i.e. by an internal tendency, there would not be variations in timing and in amplitude nor a parallelism with respect to the lunar motion. Secondly, it is not credible that the waters of basins overflow from their usual place by means of spontaneous motion. Moreover, waters have an inherent tendency to move downward, as Albumasar argues, following Aristotle’s physics. Hence it is difficult to comprehend by what natural tendency they can be induced to rise. Albumasar concludes that the cause must be extrinsic and the only ascertainable one is the Moon.

3. Pico’s criticism of the lunar explanation of the tides

The centrality of the lunar theory of the tides, as well as the breadth of discussion in Albumasar’s *Introductorium*, meant that the critics of astrology could not ignore the topic. Giovanni Pico della Mirandola dedicated several pages to it in his famous argument against it, *Disputationes adversus astrologiam divinatricem* (Disputations against Divinatory Astrology, published posthumously in 1496). Chapter xv of the third book is entitled “The Sea Tides Can Be Explained through a Cause Different than the Moon; Even if This Were the Explanation, It

⁹ Ibid., c3v.

¹⁰ Ibid., c2r: “Est autem accessus quidem aque calidior et recessus frigidior. In accessu namque ex imis abyssis ebulliunt in recessu forinsecus expanse infrigidant.”

Would Not Support Astrology” (*Aestus maris in aliam causam quam in Lunam referri posse, in quam et si referatur nihil inde iuvari astrologiam*). The question, Pico observes, is complex given that *everyone* is of the opinion (*cum omnibus videatur*) that the Moon is the origin of the phenomenon.

Pico begins with a series of considerations taken from Adelard of Bath who explained the tides as a motion caused by the tendency of waters separated by extensions of land to reunite, according to the principle that “the elements, as parts of a whole have a natural tendency to restore the [original] integrity” (*naturali propensione feruntur elementi cuiusque partes ad suam integritatem*).¹¹ This tendency did not coincide with the natural motion of the element but rather a law regulating the behaviour of the parts.¹² As one reads in Pico, the phenomenon can be explained without recourse to celestial causes simply by considering the tides as a process of boiling followed by an expansion of the element (i.e. *accessus*) and then by cooling and contraction (*recessus*):

Therefore, some will consider the following cause of the sea tides as clear enough and sufficient: that vapours and [...] winds rise from the earth and water so that wind and turmoil is to be found in the water and, in particular, that this motion and impulse, and the mixing of vapours, warms [the water]. As a consequence, it needs a wider space to expand. By contrast, if that force extinguishes because the vapours are dissolved, [the waters] go down and flatten. They contract in narrow places and descend from the places they occupied.¹³

Pico stresses that this explanation is based on nothing other than the *nature* of the sea. He concludes by referring to natural reason and experience: “If [this explanation] is in agreement with natural reason and if it is in agreement with experience, why should we regard them as less likely? Moreover, why should we add the Lunar motion to these causes [...]?”¹⁴

Pico then refutes the “Saracens,” supporters of a celestial theory of the tides, which violates rational-empirical evidence. He names two of them: Albumasar (*Aboasar*) and

¹¹ Giovanni Pico della Mirandola, *Disputationes adversus astrologiam divinatricem* III 15, in *Opera omnia*, vol. 1 (Hildesheim-Zürich-New York: Olms, 2005), p. 488.

¹² Ibid.: “Hunc accendi recendique motum naturalem esse aquae non quatenus aqua est, sed quatenus partes habet elementi principalis, ibjectu molis terrenae diremptas et separatas.”

¹³ Ibid., pp. 488-489: “Poterit autem cuipiam hinc apparere satis aperta et sufficientis causa, marinae reciprocationis, siquidem de tali terra et aqua, vapores [...] ventique suscitantur, unde in aqua sit ventus, tumultus, praesertim quod ex motu impulsuque isto, et vaporum admixtione, calescit, quare locum quaerit ampliolem quo se diffundat. [...]. Rursus ubi vis illa dissolutis vaporibus conflagrescit, subsidunt atque sternuntur, et in angustiis se contrahentes, ab occupatis locis abscedunt.”

¹⁴ Ibid., p. 489: “Quae si rationi consonant naturali, si consonant experimentis, cur parum probabilia iudicari debent? Aut cur necessarium praeter has causas addere Lunae motum [...]?”

Alpetragius. The former is mentioned in regard to lunar causation. The latter is attributed with a general theory of celestial causation of the sublunar elements.¹⁵

Alpetragius (al-Bitruji, 11th century), a contemporary and fellow countryman of Averroes (Ibn Rushd), dealt with the motion of the elements (*motus elementorum*) in the fourth chapter of his homocentric astronomical work *De motibus celorum* (On Celestial Motions), which strongly influenced Girolamo Fracastoro and the Venetian Averroists.¹⁶ As one reads, all the sublunar elements are affected by the circular motion of the stars but in a progressively reduced manner the farther they are from the celestial sphere. Fire is moved almost at the same velocity as the celestial bodies, as evidenced by comets or similar ‘meteorological’ phenomena (*quod apparet de similibus stellarum que videntur in quibusdam horis incensis in aere*). Air is slower; whereas the motion communicated by the heavens to water is that of the tides, attributed by many (mistakenly) to the Moon:

And the motion of the water is less rapid than the air. For this reason it is believed that its motion follows that of the Moon, in consideration of the closeness of their motions (of the Moon and the sea); and hence, it was also believed that it [the sea] follows it [the Moon] and is attracted by the latter.¹⁷

Al-Bitruji’s explanation of the tides is based on the action of the heavens, the *ponderositate* (weight) of the waters and their *multitudo* (probably meaning volume). The movement of the tides would go unnoticed if it could not be seen on the seashores (*ubi non invenitur nisi una ripa propter sui magnitudinem et profunditatem*). The east to west flow of the waters, of celestial origin, strikes the coast. The result is an oscillating motion of the tides due to a triple impulse: the westward tendency (communicated by the stars), a resistance in the opposite direction (because of the “weight”) and a downward resistance, called *multitudo* or quantity (which is the natural tendency of waters):

¹⁵ Ibid.: “Alpetragius attulit huius motus coelestem causam, nec a Luna, verum a diurno motu quo movent omnia. Sed inferiora minus. Ignis enim sphaera rotatur in orbem. Inordinatus motus in aere fit, quae in aqua definit in accessum atque recessum.”

¹⁶ Al-Bitruji [Alpetragius], *De motibus celorum*, ed. Francis J. Carmody (Berkeley-Los Angeles: University of California Press, 1952), pp. 80-82. Cf. Di Bono, *Le sfere omocentriche di Giovan Battista Amico nell’astronomia del Cinquecento*.

¹⁷ Ibid., p. 81: “Et motus aque est minus velox motu aeris; et propter hoc creditur quod ipse sequitur in motu suo motum Lune propter propinquitatem suorum motuum (Lunae scilicet et maris); et propter hoc credebatur quod ipsum sequebatur ipsam et incurtat ab ipsa.”

The motion of the water from the east is a motion that imitates that [motion] which is above it. Its motion backwards is due to its weight [*ponderositas*] and its downward thrust is due to its quantity [*multitudo*].¹⁸

“But it is evident—al-Bitruji concludes—that the earth rests in its entirety”¹⁹ even though its parts can be subjected to local movements. In short, the work of this medieval scholar provides an account of the phenomenon of the tides within an astronomical-cosmological context. The tides are explained in causal terms and without recourse to ‘occult’ or hidden forces (*virtutes occultae*). The explanation is based on considerations concerning the nature of the waters and the universal circulation of the cosmos toward the west rather than by the distant action of the Moon.

Let us return to Pico’s *Disputationes*. After maintaining the plausibility of a non-astral explanation of the tides, Pico admits but does not concede (for the sake of argument) that the moon might be responsible for them. He stresses, however, that the only possible actions of the heavenly bodies on terrestrial ones occur through motion or light and not through occult influences (*occultis influxibus*). “Whatever of these traditions one accepts, it is clear that we are not forced to ascribe any new power to the Moon producing the motion of the sea, except for motion and light.”²⁰ The concomitance of lunar motion and tides can be considered a sort of parallelism rather than a causal relationship: “if we allot that effect to the Moon, we will refer such motion to a tacit natural harmony according to which motion is imitated when the occasion is given, as it [the sea] rises when the Moon rises and descends when the latter sets.”²¹ However, despite whatever concession might be made to the astrologers as far as natural philosophy is concerned, Pico does not compromise regarding the ethical implications. It is not permissible to infer from the observation of celestial causes that human actions, be they small or large (*et parva et maxima*), individual or collective, are guided and sustained (*duci et regi*) by stars and planets.²²

To summarize, Albumasar provided to the Latin Middle Ages and the Renaissance an astrological interpretation of the tides based on the remote action of the Moon on the waters of our planet. This influence was an unspecified force of affinity (*virtute cognationis*). Such

¹⁸ Ibid.: “Tunc motus aque qui est a parte orientis est motus quo consequitur ipsum quod est superius ad ipsum, et sua reversio est propter eius ponderositatem, et eius declinatio deorsum propter sui multitudinem.”

¹⁹ Ibid.: “Sed terra apparet quod quiescit simpliciter in toto.”

²⁰ Pico, *Opera, cit.*, p. 492: “Verum quaecunque potius recipiatur harum traditionum, patet nihil nos cogi novam comminisci potestatem in Luna, praeter motum et lucem, quare mare commoveat [...]”

²¹ Ibid., p. 491: “[...] nos si pertinet ad Lunam talis effectus, ad eis id motum referamus quem tacito naturae consensu, occasione motus imitatur, quare ascendit cum ascendente [Luna], descendit cum descendente.”

²² Ibid., 490.

an explanation approaches in many ways the modern post-Newtonian theory based on the law of universal gravitation but was accused of being an undue recourse to occult influences (*occulti influxus*). Pico's refutation, included in the fiercest anti-astrological indictment of the 15th century, appears to be particularly important. It opened two paths to those who shared his suspicion of an astrology-based theory applied to the lunar explanation of the tides: either reject the lunar influence *in toto*, and thus venture into a search for a new explanation, or accept some parallelism in which the Moon was granted nothing more than an action through movement and light. Pico provided an intrinsic explanation of the phenomenon (to him rational and empirical) relating the *aestus maris* to a kind of alternation of expansion of the waters by boiling and contraction of them by cooling.

4. Giordano Bruno's vitalistic approach to the tides

The denial of the lunar causation of the tides, if placed in relation to the criticism of astrology, allows us to understand some fundamental reasons for the revision of the explanation of the phenomenon during the 16th and 17th centuries. Among other sources, in the fifth dialogue of *La cena de le Ceneri* (The Ash Wednesday Supper, 1584), Giordano Bruno denies that the tides can be due to the distant action of the Moon and proposes an alternative theory, which we can call 'vitalistic'. He accepts that there is a correspondence between the positions of the Moon and the movements of the waves, but this depends on a kind of harmony of nature by which the laws regulating one process can correspond to those governing a parallel one without there being a causal link. This means that the positions of the Moon can be considered *signs* of the rise and fall of the sea level without being considered a *cause*.

The starting point is a type of astrobiology according to which the planets' bodies "possess the principle of intrinsic motion [through] their own natures, their own souls, their own intelligence."²³ Since the principle of motion is inherent to the moving object, there is no need to invoke some "tractive or impulsive force or something similar, which cannot be done without the contact of at least two bodies."²⁴ Bruno maintains that each body that moves without *appreciable contact*, as if affected by another *driving or attracting* body, should be explained on the basis of a spontaneous internal principle (*appulso*). Everything that moves

²³ Giordano Bruno, *The Ash Wednesday Supper*, 206. Cf. Bruno, *La cena de ceneri*, in *Opere italiane* (Torino: UTET, 2004): pp. 427-589, p. 547f.: "Questi corridori hanno il principio di moti intrinseco la propria natura, la propria anima, la propria intelligenza."

²⁴ *Ibid.*, 206. Cf. Bruno, *La cena*, 548: "virtù trattiva, o impulsiva, et altre simili, che non si fanno senza contatto di dui corpi almeno."

with respect to something else without contact and as if propelled by some deprivation or desire does so by spontaneous motion: it is the iron object that moves the magnet, not the latter that forces the movement; similarly the straw moves spontaneously toward the amber, the feather toward the jet, the sunflower toward the Sun. The motion of the tides must also be discussed and explained in this perspective:

“Upon the consideration that nothing moves in space on account of an extrinsic principle, without a contact more forceful than the resistance of the medium, depends the further consideration that it is solemn foolishness and an impossible thing to persuade an orderly mind that the moon moves the waters of the sea (causing tides), [...] since for all these things it is properly a sign and not a cause. It is a sign and indication, I Say, because the observation of these things [together] with certain dispositions of the moon [...] proceeds from the order and correspondence of things, and from the laws of one mutation which are in conformity and correspondence with the laws of another.”²⁵

Shortly we will consider another vitalistic explanation, the one proposed by Francesco Patrizi based on the idea of an intrinsic impulse as the origin of the motion of the seas and that this impulse is similar to the one that moves the planets in ethereal space.

Bruno concludes his remarks on the tides with a criticism of *so many strange philosophies* that confuse *signs* and *causes*. The reference is to astrology, which mistakenly believes that the movements of the stars are causes and not *signs* of earthly affairs.

Similarly geometricians often confuse *signs* and *natural causes*, for example when they state that the perpendicular rays of the Sun cause more heat, when the cause of the heat can only be material, i.e. the greater or lesser persistence of the Sun on the Earth. “It is one thing to play with geometry and another to verify with nature. It is not lines and angles which make fire heat more or less, but distance and nearness, long and short duration.”²⁶

5. *Mechanical explanations of the tides: Galileo’s teacher Cesalpino*

²⁵ Ibid., 207. Cf. Bruno, *La cena*, 548f.: “Da questo considerar che nulla cosa si muove localmente da principio estrinseco senza contatto più vigoroso della resistenza del mobile, dipende il considerare quanto sii solenne goffaria, e cosa impossibile a persuadere ad un regolato sentimento, che la luna muove l’acqui del mare, caggionando il flusso in quello [...]: atteso che quella [...] è propriamente segno, e non causa [...], perché il vedere queste cose con certe disposizioni della luna [...] procede da l’ordine e corrispondenza delle cose, e le leggi di una mutazione, che son conformi o corrispondenti alle leggi de l’altra.”

²⁶ Ibid., 208. Cf. Bruno, *La cena*, 549f.: “Altro è giocare con la geometria, altro è verificare con la natura. Non son le linee e gli angoli che fanno scaldar più o meno il fuoco; ma le vicine e distanti situazioni, lunghe e brieve dimore.”

Giovanni Aquilecchia highlighted a possible link between Bruno's rejection of the remote action of the Moon on the tides and the much better known and articulated discourse on the tides by Galileo in the concluding part of *Dialogo sopra i massimi sistemi del mondo*. Also for Galileo the tides are not ascribable to an action of the Moon but constitute tangible proof of the motion of the Earth.²⁷ His explanation, on closer inspection, is rather mechanical strictly speaking and not based on a vitalistic and teleological concept of the inherent impulse of bodies to motion or to some tendency to self-preservation. If there is a common foundation of the criticism of the lunar theory in Bruno and Galileo it is the criticism of astrology and the distant influence of the stars, not of the explanation provided.

The fundamental thesis of "Day Four" of the *Dialogue Concerning the Two Chief World Systems: Ptolemaic and Copernican* (1632), a section entirely dedicated to the tides, is "that if the terrestrial globe were immovable, the ebb and flow of the oceans could not occur naturally; and that when we confer upon the globe the movements just assigned to it [by Copernicus], the seas are necessarily subjected to an ebb and flow agreeing in all respects with what is to be observed in them."²⁸ Galileo sought in the tides an incontrovertible proof of the Earth's motion. Renouncing both the action of the Moon and gravitational considerations, he explained the phenomenon in what we can call inertial terms. The rise and fall of the waters depend on the combined action of daily axial rotation and annual revolution.²⁹

Galileo claimed the absolute originality of his explanation of the tides. Certainly he took a step forward with respect to his predecessors in combining tidal theory, Copernican hypotheses and mathematical physics. Nevertheless, in light of the broad Renaissance discussion on terrestrial motion (*motus terrae*), elemental motion (*motus elementorum*) and tides, the words of the Copernican Salviati in Galileo's *Dialogue* sound ironic: "[...] what I am about to say, I propose merely as a key to open portals to a road never before trodden by anyone [...]."³⁰ Indeed, the portal (*la porta*) and the road (*la strada*) for an explanation of the tides based on the Earth's motion rather than on "occult qualities [...] and similar idle

²⁷ Giovanni Aquilecchia, "I *Massimi Sistemi* di Galileo e *La Cena* di Bruno (per una comparazione tematico-strutturale)", 491-492.

²⁸ Galileo Galilei, *Dialogue Concerning the Two Chief World Systems: Ptolemaic and Copernican*, 417. Cf. Galilei, *Le opere: Nuova ristampa dell'edizione nazionale* (Firenze: Barbera, 1968) (from now onwards EN) VII, 443: "che quando il globo terrestre sia immobile, non si possa naturalmente fare il flusso e reflusso del mare; e che quando al medesimo globo si conferiscano i movimenti già assegnatili [da Copernico], è necessario che il mare soggiaccia al flusso e reflusso."

²⁹ For a recent examination of Galileo's tidal theory, see Clutton-Brock and Topper, "The Plausibility of Galileo's Tidal Theory".

³⁰ Galilei, *Dialogue*, 418. Cf. Galilei, EN VII, 444: "E quello che io sono per dire, lo propongo solamente come una chiave che apra la porta di una strada non mai più calpestata da altri."

phantasies” (*qualità occulte e [...] simili vane immaginazioni*) had already been opened by one of Galileo’s Pisan teachers, Andrea Cesalpino. Let us dwell briefly on his theory.

In Chapter III 5 of *Peripateticae quaestiones* (Peripatetic Questions, 1571), Cesalpino, the famous professor of the University of Pisa, demonstrates the thesis that “the flow and ebb of the sea is produced by the motion of the Earth and not of the Moon” (*maris fluxum et refluxum ex motu Terrae non Lunae fieri*).³¹ He discusses not only the motion of the waters but also that of the Earth. Firstly, Cesalpino refutes the theory of the Moon’s influence on the movements of the sea. The observation of a correspondence between lunar motion and tides is the basis for the belief that there is a causal relationship between the former and the latter. Cesalpino argues, however, that if this were true the seas would always flow in the same direction, accompanying the Moon, instead of having an alternate motion.

Secondly, the remote action is inexplicable. By what mystery would the Moon act on water and not the intermediate elements fire and air (ordered according to the peripatetic doctrine of natural places)? “In fact [the Moon] cannot move [the water] by itself, because there is no contact.³² Or is it necessary to assume that there is a hidden virtue (*virtus quaedam occulta*) such as the one the magnet exerts on iron? But even in this case the *virtus* must communicate the motion through an intermediate motion.

Thirdly, Cesalpino deals with the theory that the Moon acts on the waters through its light, which would cause heating (*calefactio*), expansion of the waters (*tumor*) and a consequent flow (*exundatio*). As we have seen, this was the theory considered most plausible by Pico. Cesalpino disagrees. If it were true, the same “sympathetic” action (*huiusmodi sympathia in aqua*) would have a greater effect on concentrations of water smaller than seas and oceans, as in the case of lakes and ponds: “in fact, that which is smaller is moved by the same force more easily.”³³

After clearing the way of arguments based on the Moon’s action, Cesalpino moves on to consider Aristotle’s *Meteorologica* II 2 in which the origin of the tides is sought in the combination of two causes. The first is the massive entry of water into the sea by rivers, especially in the eastern Mediterranean Basin. The waters of the Mediterranean flow from east to west, from the Black Sea and the Aegean to the Tyrrhenian Sea. The second cause is an oscillatory balancing (*libratio*) of the waters: “another one is the measured

³¹ I discuss Cesalpino’s theory in “Riflessioni sul moto terrestre nel Rinascimento: tra filosofia naturale, meccanica e cosmologia”, in *Scienza e rappresentazione. Saggi in memoria di Pierre Souffrin*, ed. by Pierre Caye and Pier Daniele Napolitani (Firenze: Olschki, 2016), pp. 285-300.

³² Andrea Cesalpinus, *Peripateticarum quaestionum libri quinque* (Venetiis: Iuntas, 1571), f. 60r: “Nam [Luna] se ipsa [aquam] movere non potest, quia non tangit.”

³³ Ibid.: “quod enim minus est, ab eadem virtute facilius movetur.”

oscillation/balancing of the entire sea which in fact often oscillates [*libratur*].”³⁴ The parallel between the oscillatory motion of waters and the behaviour of a balance, implicit in the concept of *libratio*, does not convince Cesalpino. If in fact the weight were greater in one part of the system in equilibrium it follows that there would be not a rebalancing of the distribution of the waters but rather a flow in a single direction:

Aristotle assumes that the same balancing that occurs to a steelyard can be ascribed to the sea. If they receive an initial motion, they alternatively incline towards one side and the other, owing to the equality of the weights. Actually, if the weight on the one side would be greater, the whole would incline and would not be lifted back again.³⁵

Cesalpino additionally observes that if the element of water encloses that of earth everywhere, there would be no explanation why an alternate motion like the one in question originates.³⁶ It could certainly not be a ‘violent motion’, according to the Aristotelian distinction between natural and violent motions. Indeed “nothing produced with violence is perpetual” (*nullum violentum sit perpetuum*).³⁷

A similar and different criticism of the passage of *Meteorologica* in question is found in Telesio’s *De mari* (vi-vii). Also to him Aristotle’s *libratio* does not seem plausible, “because the Earth is spherical, therefore it is impossible that its northern part, nor any other of its parts, can be higher or lower.”³⁸ Hence the parallel of the balance scale is wrong, but even if one accepts such an absurdity, Telesio writes, one must consider the phenomenon of balancing and draw consequences that are different (both from Aristotle and from Cesalpino):

If it has been inclined and no external force pushes nor moves it, it will remain forever at rest. Aristotle should strongly agree on this, as he upholds that all the elements [...] are at rest in their natural place and benefit from immobility.³⁹

³⁴ Ibid.: “alteram autem esse modicam quandam totius maris librationem: huc enim illuc libratur saepe.”

³⁵ Ibid.: “Quod igitur stateris accidit aequilibris, mari vult contingere Aristoteles. Accepto enim principio motus inclinant modo in unam partem, modo in alteram saepe, propter aequalitatem ponderis. Nam si in altera parte pondus superaret, in eam totum vergeret, nec in alteram resurgeret.”

³⁶ This is an old argument, used in antiquity by Strabo (basing himself on Archimedes) against Eratosthenes, supporter of a hypothesis similar to that of Aristotle mentioned herein.

³⁷ Cesalpino, *Peripateticae quaestiones*, f. 60r.

³⁸ Telesio, *De mari* vii, *ed. cit.*, p. 101: “Per che la terra è sferica, né può parere che la parte boreale, o qual si voglia altra sia più alta o più bassa.”

³⁹ Ibid.: “Ma dove gli sia una volta declinato, quivi non essendo da alcuna forza esterna sospinto o mosso, rimarrà perpetuamente immobile; e questo debbe parere particolarmente ad Aristotile, al quale pare che tutti li primi corpi [...] sieno nel proprio loco immobili, e che della immobilità godino.”

Let us return to *Peripateticae quaestiones*. According to Cesalpino's reasoning, there remains only one option: that the tides are an "incidental motion" dependent on the *continens*. The *ex extrinseco* violent motion has already been excluded by the observation that no violent action can last uninterruptedly. On the other hand, he excludes that it could be a "natural motion". According to Aristotle, each element has a unique natural motion and, in this case, the four elements would have a single downward or upward vertical tendency (or better *toward the centre* and *away from the centre* of the elements) to return to their natural place. If the tides were a natural motion of the water it follows that this element has more than one natural motion. Thus having eliminated the explanation based on a cause *per se*, Cesalpino investigates the incidental one, communicated by the "container". The tides would result from the action of one of the two elements contiguous to the sphere of water, i.e. air or earth. Since the only motion of air is the disordered one of the winds, which at best can ruffle the waters of the seas, Cesalpino infers that the motion of the tides depends on that of the Earth. Q.E.D.: *maris fluxum et refluxum ex motu terrae fieri* (the ebb and flow of the sea is produced by the motion of the Earth).

Cesalpino explains that the tides should be conceived in a manner similar to the behaviour of water in a low, wide container in motion. At first the liquid in the container resists the motion, then follows it and quivers as if seeking its equilibrium:

As one can see in a small vessel, which is more wide than deep, if it is moved the water first resists in the part opposite [to the direction of the motion] and often oscillates [*libratur*] here and there searching for its equilibrium. Thus, after the Earth has moved a bit, the water, which has first remained behind and is out of balance, flows in the other direction, but surpassing the point of equilibrium as a consequence of the imparted motion. For the same reason, it returns back, in the opposite direction, and continues to do that in the search for an equilibrium, in which it can rest naturally.⁴⁰

The next step is to identify the nature of the Earth's motion, the necessity of which is evident from the discussion on the tides. Cesalpino observes that the movement of the container, i.e. of the Earth, will cause greater agitations where the masses of water are greater, i.e. in the

⁴⁰ Cesalpinus, *Peripateticarum quaestionum libri*, f. 60v: "[...] ut videre licet in parvo vase, cuius amplior sit latitudo quam profunditas: si enim dimoveatur, resistit aqua a tergo priusquam in opposita partem, et saepe huc atque illuc libratur quaerens aequilibrium. Cum igitur terra modice praetergressa fuerit, aqua autem posterius derelicta, extra suum aequilibrium existens, in alteram partem ruit, sed ultra aequilibrium ob acceptum motus principium. Inde iterum ob eandem causam in oppositam partem vergit, et saepe id facit, quaerens aequilibrium, in quo naturaliter quiescat."

oceans. Consequently the frequency and amplitude of the tides will not be equal in all the seas: “from this it is evident that the tides do not always follow the Moon.”⁴¹ Moreover the *circumvolutio* of the Earth must be minimal (*parva tamen*), otherwise the marine fluctuations should be much greater than they appear. Such motion will have consequences on celestial phenomena, a *variatio stellarum fixarum* which Cesalpino identifies in the millennial motions. According to him, the *theorica planetarum* (planetary theory) can do without the spheres placed by astronomers beyond the eighth one, or rather those assigned, according to Peurbach, to the precession of the equinoxes and its irregularities (the so-called *titubatio* or *trepidatio*):⁴²

If the sea perpetually oscillates forth and back, it is necessary that the Earth moves. If this is correct, it is necessary that the position [*aspectum*] of the fixed stars changes accordingly. It is the motion of trepidation, discovered by the astronomers in the eighth sphere, that most likely depends on the motion of the Earth rather than on its own motion [of the eighth sphere]. Moreover, if this oblique and discontinuous motion of the Earth is sufficient to account for the observed change of position [*aspectus*], one does not have to posit any other spheres above the eighth sphere.⁴³

This is a moderately Copernican position. Of the three terrestrial motions postulated by Nicolaus Copernicus in *De revolutionibus orbium coelestium* (On the Revolutions of the Celestial Spheres, 1543), Cesalpino retains only the one that seems least plausible to the modern reader: neither the diurnal rotation nor the annual revolution but the third motion called *motus declinationis* which would account for the precession of the equinoxes, for the variability of the Earth’s axis as well as the presumed irregularities of the precession.

Thus Cesalpino’s doctrine is a historical precedent of the Galilean theory of the tides. Galileo’s basic thesis is very close to that of his teacher in Pisa, beginning with the experiment (mind experiment or not) of the ‘vessel’: “But if, by simply setting the vessel in motion, I can represent for you without any artifice at all precisely those changes which are perceived in the waters of the sea, why should you reject this cause and take refuge in

⁴¹ Ibid., f. 61r: “ex quibus etiam patet non ubique aestus insequi Lunae cursum.”

⁴² I dealt with this topic in relation to Peurbach, Copernicus and Bruno in Omodeo, “Giordano Bruno and Nicolaus Copernicus: The Motions of the Earth in *The Ash Wednesday Supper*”, 49-51.

⁴³ Cesalpinus:1571, f. 61r; “Si enim libratur huc illuc mare perpetuo, necesse est terram moveri. Si vero hanc, necesse est aspectum stellarum fixarum variari. Motus ergo trepidationis ab astrologis inventus in octava sphaera, ex motu terrae rationabilibus contingit, quam ex motu illius. Si igitur parvus hic atque obliquus et inaequalis terrae motus sufficit ad mutationem aspectus, quae notata est, non sunt ponendi alii orbis supra octavam sphaeram.”

miracles?”⁴⁴ The same applies to the conclusion: “[...] [Y]ou have explained very persuasively why it would be impossible for the observed movements to take place in the ordinary course of nature if the basins containing the waters of the seas were standing still [...]”⁴⁵ Galileo and Cesalpino were both driven by a radical rejection of the lunar option, which introduced into physics occult qualities and remote influences. Galileo’s anti-astrological rancour is seen for example in the following passage concerning the monthly and annual periodicity of the tides, to be considered along with the daily periodicity:

“Now two other periods occur, the monthly and the annual. These do not introduce new and different events beyond those already considered under the diurnal period, but they act upon the latter by making them greater or less at different parts of the lunar month and at different seasons of the solar year - almost as though the moon and sun were taking part in the production of such effects. But that concept is completely repugnant to my mind; for seeing how this movement of the oceans is a local and sensible one, made in an immense bulk of water, I cannot bring myself to give credence to such causes as lights, warm temperatures, predominances of occult qualities, and similar idle imaginings. These are so far from being actual or possible causes of the tides that the very contrary is true. The tides are the cause of them; that is, make them occur to mentalities better equipped for loquacity and ostentation than for reflections upon and investigations into the most hidden works of nature. Rather than be reduced to offering those wise, clever, and modest words, “I do not know,” they hasten to wag their tongues and even their pens in the wildest absurdities.”⁴⁶

Galileo acknowledged Cesalpino as somebody who anticipated his explanation of the sea tides in a letter to Cesare Marsili in which he made specific reference to the *Dialogo*.⁴⁷

⁴⁴ Galilei, *Dialogue*, 421. Cf. Galilei, EN VII, 447: “Ma se co’l far muovere il vaso, senza artificio nessuno, anzi semplicissimamente, io vi posso rappresentar puntualmente tutte quelle mutazioni che si osservano nell’acque marine, perché volete ricusar questa cagione e ricorrere al miracolo?”

⁴⁵ Ibid., 461. Cf. Galilei, EN VII, 486: “Molto concludentemente si dichiara, che stando fermi i vasi contenenti le acque marine, impossibil sarebbe, secondo il comun corso di natura, che in esse seguissero quei movimenti che seguir veggiamo.”

⁴⁶ Ibid., 445. Cf. Galilei, EN VII, 470: “Seguono ora gli altri due periodi, mestruo e annuo, li quali non arrecano accidenti nuovi e diversi, oltre a i già considerati nel periodo diurno, ma operano ne i medesimi con rendergli maggiori e minori in diverse parti del mese lunare ed in diversi tempi dell’anno solare, quasi che e la Luna e il Sole entrino in parte dell’opera e nella produzion di tali effetti: cosa che totalmente repugna al mio intelletto, il quale, vedendo come questo de i mari è un movimento locale e sensato, fatto in una mole immensa d’acqua, non può arrecarsi a sottoscrivere a lumi, a caldi temperati, a predomini per qualità occulte ed a simili vane immaginazioni, le quali *tantum abest* che siano o possano esser cause del flusso, che per l’opposito il flusso è causa di quelle, cioè di farle venire ne i cervelli atti più alla loquacità ed ostentazione, che alla specolazione ed investigazione dell’opere più segrete di natura; li quali, prima che ridursi a profferir sulla savia ingenua e modesta parola *Non lo so*, scorrono a lasciarsi uscir di bocca, ed anco della penna, qual si voglia grande esorbitanza.”

⁴⁷ Galilei to Marsili (Florence, 20 March 1632), EN XIV, 335.

However, he also stressed that the accuracy of his *fully* Copernican account was superior and unique.

6. Pandolfo Sfondrati's middle way: the Sun's heat as the cause of the tides

Alongside those who wrestled with vitalistic, peripatetic or mechanical theories aimed at refuting the idea of a remote action of the Moon, there were those who took the other path opened by Pico aimed at limiting the action of the heavenly bodies to motion, light and heat. For example, a theory based on the action of the Sun's heat was proposed by an eclectic atomist from Cremona, Pandolfo Sfondrati, in a work entitled *Causa aestus maris* (The Cause of Sea Tides). The first edition, now lost, must have appeared in Turin around 1582; a second was printed in Ferrara by the typographer Mammarello in 1590 with the *imprimatur* of the local Inquisition and the indication of approval of the preceding edition by the Inquisitor of Turin.⁴⁸ Hence the book appeared in the period between the first (1570) and second edition (1590) of Telesio's opuscula, during which Cesalpino's *Peripateticae quaestiones* (1571), Bruno's *La cena de le Ceneri* (1584) and the third edition of Telesio's magnum opus (1586) were also published.

Sfondrati, linked to the Savoy court, belonged to a distinguished Cremonese family which, in the person of the Milanese senator Paolo Sfondrati, represented the Habsburg interests, i.e. of Milan and of Philip II, in Turin. Paolo's brother was Nicolò Sfondrati who, with the name of Gregory XIV, occupied the papal throne between 1590 and 1591. Pandolfo dedicated the second edition of *Causa aestus maris* to him.

In this book, Sfondrati begins with eclectic positions in philosophy. He argues the concordance between Plato and Epicurus in natural philosophy: "I found so much solidity in the teachings of the academics and the Epicureans as far as the natural causes are concerned that I would not move away from their schools [*gremium*]." ⁴⁹ On this background, Sfondrati proposes an original heliothermal explanation of the tides. The centrality of the action of the Sun's heat is emphasized from the first lines of the book, with recourse to a pseudo-epistemological comment on the term *aestum*: "They derive the word 'aestum', tides, from

⁴⁸ Pandolfo Sfondrati, *Causa aestus maris* (Ferrariae: apud Benedictum Mammarellum, 1590), f. 44v: "Frater Vincentius Vaschinus de Calvisano Vicarius generalis Sanctiss. Inquisitionis Status Sereniss. Ducis Ferrariae, visa subscriptione Reverendi Patris Inquisitoris Taurini 1582, a quo probatum fuit opus in exemplari veteri, imprimatur."

⁴⁹ Ibid., f. 31v: "Me tantam naturalium causarum soliditatem in dogmatibus Academicorum et Epicureorum reperisse, ut ab eorum gremio discedere nequeam, nec nisi ad satietatem eorum aquis etiam, atque etiam ablutum, curare ad alios me conferre [...]."

‘aer’, air, and assume that it properly means warmth. From it derives the word ‘aestas’, summer.⁵⁰ Like Telesio, Sfondrati introduces the ‘heliothermal’ theory of the tides with the metaphor of a boiling pot in which the vapours caused by the warming tend to move upward, producing a rise.⁵¹

Sfondrati hypothesizes that the tides are generated by the action of the Sun on the water particles and thus the phenomenon should be considered in terms of changes in the mutual relations of the Sun and the Earth. This would result in a perpetual flow of the seas and oceans around the Earth, a circular motion similar to that of the celestial revolutions: “The sea eternally flows, running through the entire terrestrial globe, with the same order of all celestial bodies.”⁵²

The contrary motion, of ebbing of the tides, would be linked to the collision of the primary flow against barriers, particularly in the vicinity of straits. These would hinder the impetus of the waters and partly push them back, producing recoils strong enough to explain the eastward tidal ebb.⁵³

7. Patrizi’s appraisal of the debate about the tides

The major philosophical work by Francesco Patrizi, *Nova de universis philosophia* (New Philosophy on Universal Things, 1591), was published less than a year after the second edition of Sfondrati’s *Causa aestus maris* by the same Ferrarese typographer; it was dedicated to the same patron, Pope Gregory XIV, and contained a broad discussion of the tides. Six chapters of *Pancosmia* (xxiv-xxix), the fourth book of *Nova de universis philosophia* (which followed *Panaugia*, *Panarchia* and *Pamsychia*), were devoted to the subject of waters and seas.⁵⁴ The specific topic of the tides was dealt with in Chapters xxviii and xxix.

⁵⁰ Ibid., f. 3r: “Aestum ab aere deductum volunt, et proprie calorem significare, unde aetiam aestatem derivatam esse.” Cfr. f. 4r: “aestum non ab aere simpliciter, sed ab aere usto derivatum esse [...] quasi quaedam ebullitionem, unde aestatem, et per methaphoram aestum maris nominata esse videmus [...]”

⁵¹ Ibid., f. 3r.

⁵² Ibid., f. 8r: “Mare transiit universum terrarum globum perenniter currendo in orbem circulariter, eodem ordine quo sydera omnia.” Cfr. f. 28v: “[...] et ideo mare suo cursu, cursum stellarum ab aeterno imitatur.”

⁵³ Ibid., cap. 3, *Causa vera aestus marini*, ff. 8r-v: “Cum via illa a Natura fuerit constituta, per quam Mare transiens universum terrarum globum perenniter currendo in orbem circuiret, eodem ordine quo sydera omnia, licet partim velocius, partim tardius indesinenter volvuntur, per illasque [Magellanicas] fauces concitato cursu ad rapidi flumini instar ferantur, neque omnes uno impetu tantorum Marium undae, per angustas huiusmodi fauces partransire possint, coguntur ex fuga contrarii contra oppositas ex adverso aquas sequaces regurgitare, et cum unda palpitatione quam vocant, undam proximam impellat, de necessitate ad oppositas partes quantumvis remotas, aestus concitatur, maior aut minor iuxta oppositionis distantiam, et aquarum multitudinem.”

⁵⁴ xxiv De aqua et mari; xxv De aquae rotunditate; xxvi An aqua et terra unum efficiunt globum; xxvii De maris universi motibus; xxviii De maris afluxus, et refluxus varietate; xxix De causis afluxus et refluxus maris.

Chapter xxviii of *Pancosmia*, entitled “De maris affluxus et refluxus varietate” (Various [Opinions] on the Flow and Ebb of the Sea), is an overview of the positions expressed in the intense 16th century debate. Patrizi reviews the extensive 16th-century literature starting with *De fluxu et refluxu maris* (1588) by the physician and natural philosopher Federicus Chrysogonus of Zadar.⁵⁵ The latter had written about the variable periodicity of the tides, attributed to the combination of solar and lunar cycles and computed starting from the conjunction of the two heavenly bodies. Patrizi considers Chrysogonus the first of a host of Aristotelians who followed the Greek philosopher more or less slavishly. They include the Paduan professor of mathematics Federico Delfino, the celebrated Giulio Cesare Scaligero, the natural philosopher Girolamo Borri and the physician and astrologer Annibale Raimondo.⁵⁶

Patrizi dedicates a separate discussion to Niccolò Sagri of Ragusa (Dubrovnik), underlining his diligence and originality. This little-known Dalmatian had written a curious dialogue, *Ragionamenti sopra le varietà de' flussi del mare oceano occidentale* (Reasoning on the Variety of the Tides of the Western Ocean) (Venice, 1574) in which he tried to reconcile the doctrine of lunar traction, based on the analogy between the Moon acting on the seas and the magnet attracting iron, and the mechanical doctrine based on the analogy between the tides and the oscillations of a balance:

However, if one concedes that the opposite part does not have enough force as [to counterbalance] the Moon, I affirm that the small amount of force that you concede will be sufficient to move the waters, if not much at least a little bit [...]. This [imparted motion] added to the past motion of the Moon acts like a magnet on a compass. As one observes, when the [compass] is moved, [it keeps moving] also after [the magnet] has been removed from its sight [and] would never stop moving, if the stone was shown to it from time to time in the appropriate manner [...]. The same occurs if one touches a balance with equal weights: it needs some time to stop, alternately rising on the one side and on the other.⁵⁷

⁵⁵ Federicus Chrysogonus, *De modo collegiandi, prognosticandi et curandi febres necnon de humana felicitate, ac denique de fluxu et refluxu maris* (Venetiis: impressum a Iohanne Ant. De Sabbio et fratribus, 1538).

⁵⁶ Cf. Federicus Delphinus, *De fluxu et refluxu aquae maris* ([Venetiis]: in Academia Veneta, 1559); Girolamo Borri, *Del flusso e reflusso del mare* (in Lucca: per Busdrago, 1561) and Annibale Raimondo, *Trattato utilissimo e particolarissimo del flusso e riflusso del mare* (In Venetia, appresso Domenico Niccolini, 1589). For an essential review of the fourteenth-century debate on the tides, see Pasquale Ventrice, *La discussione sulle maree tra astronomia, meccanica e filosofia nella cultura veneto-padovana del Cinquecento* (Venezia: Istituto Veneto di Scienze, Lettere ed Arti, 1989).

⁵⁷ Niccolò Sagri, *Ragionamenti sopra le varietà de i flussi et riflussi del mare oceano occidentale, fatti da Andrea di Noblizia, Pedotto Biscaino, et Vincenzo Sabici, nocchiero, & Ambrosio di Goze, ragusei; raccolti da Nicolo Sagri, et in un dialogo dall'istesso ridotti, diuiso in due parti, ad utilità di ciascuno navigante* (In Venetia: appresso Domenico, et Gio. Battista Guerra, fratelli, 1574), p. 90: “Tuttavia qualora si volesse

Patrizi also considers Sfondrati's text in the review of his predecessors' works but he dismisses it as unfounded. The interpretation of the tides as a phenomenon resulting from the contrasted impetus of the waters, which would then be redirected eastward, seems to him implausible, indeed ridiculous.⁵⁸ Patrizi also rejects the atomistic-mechanical approach to the heliothermal theory of the tides. Indeed Sfondrati had proposed that the Sun's heat has an impact on the water particles. This rejection does not involve the heliothermal theory *in toto* nor that of Telesio in particular. As I will explain shortly, Patrizi reformulates Telesio's theory in vitalistic terms. In fact his opinion on Telesio is completely different from that on the other authors who had discussed the tides: Telesio is presented as the one who came closest to the solution of the problem.

Although critical of various aspects of his philosophy, Patrizi was an admirer of Telesio.⁵⁹ Antonio Persio had dedicated to him the opusculum *De mari* in the Venetian edition of *Opuscola* (1590). The dedication began by recalling the common philosophical discussions:

Very erudite Patrizi, you remember that, when we sojourned together in Venice, I often recommended to you Telesio's new philosophy and his approach to philosophy; I urged you to carefully read his natural books [...]. I was then glad to explain to you any passage that might be obscure to you and I solved your doubts and criticism, whenever I could.⁶⁰

concedere che la parte opposita non habbia tanta forza, quanto la Luna, almeno dico, con quella poca forza che mi concedete che lei habbia, bastaria far muovere l'acque, se non tanto almeno poco manco [...] e questo sarebbe con l'aiuto del passato moto della Luna a guisa come fa la calamita nella bussola, che quando viene ad essere mossa, avanti che si fermi, come si vede, ancor che sia levata la pietra dalla sua vista, e se da tempo in tempo convenevole li fosse rimostrata, non si fermerebbe mai [...] siccome viene a uno trabucco, o bilanza, che sia toccata, e datali causa che tra pesi equalmente, prima che si fermi tarda assai, hora alzandosi d'una parte hora dall'altra [...].”

⁵⁸ Francesco Patrizi, *Nova de universis philosophia* (Ferrariae: Apud Benedictum Mammarellum, 1590), f. 139v(b): “Paucos ante menses editus est liber, titulo *Cause aestus maris*, magno sane apparatu, sed cause redditu ut videtur et exitu ridiculo. Ait, omnes aquas ad quaslibet fauces naturali cursu properare. Oceanum, a Laboratoris terra, ad Magellanicas fauces decurrere. Tum etiam ab Oriente easdem ad fauces accurrere. Per quas cum transire nequeat omnis, inde retro regurgitat, et aestum, in Africa, atque Hispaniae littoribus excitat: aqua, aquam proximam impellente; et ea palpitatione in opposita parte intumescere. Sed quot nam horis, aut diebus, aut hebdomadibus, aut etiam mensibus ea palpitatione retrocedat? Cur item in proxima, faucibus illis Brasiliae ora tam parvum facit, in longiquissimis, Lusitano et aversus etiam Gallico, Britannico, ac Belgico? [...].”

⁵⁹ On the “friendly polemic” between Patrizi and Telesio and the involvement of Persio, see Anna Laura Puliafito, “Introduzione” a Bernardino Telesio, *Delle cose libri due (volgarizzamento di Francesco Martelli), Opuscoli (... Martelli); Polemiche telesiane (Francesco Patrizi, Bernardino Telesio, Antonio Persio)* (Roma: Carocci, 2013), pp. XXXIII-XLV.

⁶⁰ Bernardino Telesio, *Varii de naturalibus rebus libelli ab Antonio Persio editi* (Venetiis: Apud Felicem Valgrisium, 1590), rist. anastatica con introduzione di Miguel A. Granada (Roma: Carocci, 2012), f. 2r.: “Meministi eruditissime Patriti, cum Venetiis commoraremur, me tibi novam Telesii Philosophian, ac Philosophandi rationem saepius commendare, et te hortari, ut libros eius de natura legere diligenter. [...] Ego igitur libenter, et obscura quaecunque tibi essent interpretabar, et objicientium sese dubitationum scrupulos eximebam, quando poteram.”

Thus, Persio's dedication attested to an intellectual affinity and mutual respect between Patrizi and Telesio. It continues,

When I prepared the new edition of his booklet on the sea – which he had first published and was now augmented with the addition of some writings of his pertaining to the same subject – I judged that no better father and patron than you, Patrizi, could be found. Therefore, I decided to entrust it to you.⁶¹

Therefore, it is not surprising that Patrizi discusses Telesio's tidal theory in *Pancosmia*. He looks favourably on *De mari*, appreciating more the theoretical and natural profundity underlying the explanation of the tides than the special solution, which he partly rejects.

Telesio, that excellent man who dared to mint a new philosophy with the force of his ingenuity (and for this reason we admire him deeply) is the one who dealt with this issue in the most apt manner. He affirms that [1.] the sea is naturally warm and inclined to move whereby it is preserved and pleased; and [2.] thereby it flees from the action of the Sun, in order to avoid excessively evaporating. The first affirmation is perfectly true. However, I reject the second.⁶²

Patrizi accepts the basic thesis according to which the sea is warm by nature and as such is naturally led to undergo those motions that ensure its conservation. He does not accept, however, the explanation of the tides attributed solely to the action of the Sun. Telesio's heliothermal theory is not able to explain why the Sun does not act on all waters in the same way nor the difference in the behaviour of salt and fresh waters in response to its radiation. It also cannot account for the fact that similar tides are found at different latitudes, which seems to be at odds with the variations in intensity of the solar rays.⁶³ Finally Patrizi criticizes Telesio's hypothesis because it assumes seasonal variations which instead are not observed.⁶⁴

⁶¹ Ibid., f. 2v: "Cum igitur libellum eius de mari ab ipso primum editum, atque aliquibus ex eiusdem scriptis ad eandem rem pertinentibus auctum, denuo imprimendum curarem, patrem ipsi, ac patronum nullo Patricio aptiorem invenire me posse existimavi, tuaeque idcirco ipsum fidei comendare decrevi."

⁶² Patrizi, *Nova de universis philosophia, Pancosmia*, f. 140r(b)-v(a): "Telesius vir ingens, qui proprii viribus ingenii novam cudere est ausus philosophiam, quem ea de re, nos maxime admiramur, quaestionem etiam hanc, omnium optime videtur perfecturus. Mare inquit [1.] sui natura calidum, pronum est in motum, quo et servetur, et oblectetur. Et [2.] quo solis actionem fugiat, ne ab eo usto plus solvatur in vapores. Pars prior verissima est [1.]. Secunda haec non placet [2.]."

⁶³ Ibid., f. 140v(a): "Cur enim omnia maria, ea fuga non cientur? Cur aquae dulces nullae? Cum et tenuiores sint, et solutu faciliores? Sed et causa haec communis motibus maris omnibus est. Fluxus vero et refluxus propriam dicit esse, quia sol in mari ingeneret vapores, qui egressum molientes, a mari superposito prohibiti, ipsum attollunt, et agitant. Idque vere et Autumno maxime, quia medius sol, plurimos crassioresque educit

In conclusion, Patrizi rejects the theory that the tides are an effect of solar heat alone. He emphasizes above all the difficulty of matching the implications of the theory with the empirical evidence. He would not be the only one to make this criticism. For example, we can recall the much more corrosive polemic against the heliothermal theory of the tides advanced by Galileo in *Dialogo*:

“As for those who make the temperate heat of the moon able to swell the water, you may tell them to put a fire under a kettle of water, hold their right hands in this until the heat raises the water a single inch, and then take them out to write about the swelling of the seas.”⁶⁵

8. Patrizi's vitalistic theory of the tides

After discussing the hypotheses of his predecessors and his immediate interlocutors and having discussed Telesio's doctrine, Patrizi advances his own explanation in Chapter xxix of *Pancosmia*, “De causis affluxus et refluxus maris” (On the Causes of the Flow and Ebb of the Sea).

Firstly, he pronounces against the lunar causality alone.⁶⁶ The Moon, he maintains, is not alone in presiding over the tides *in universale*. The Sun is the life-giving principle that communicates warmth and life and renders earthly things apt to move. The Moon instead has a deep affinity with the Earth, which explains the parallelism of its celestial motions and numerous terrestrial cycles. Nevertheless, Patrizi believes that the celestial bodies are universal causes (*causae universales*) and thus unsuitable to account for precise phenomena

vapores. Sed causam reddat, cur in Aremoricis, et Belgicis, quae a medio sole longe distant, par aestus fit, ac in Taprobana, quae aequinoctiali et medio soli est subiecta? [...] Aestate inquit, minor sit, quia sol tenuissimos vapores gignit qui facile elabuntur, et ipsum non attollunt. At et aestate, aestus hic aequae attollitur, atque alias. Hieme item, inquit minus, quia sol languidissimus per paucos ingeneret, qui sint mare attollere impotentes. At et hoc salsum est, hieme aequalem aliis temporibus, aestum non fieri.”

⁶⁴ Ibid.: “In Pleniluniis, inquit, maior, quia multa a luna resiliens lux, multos educit vapores. At quae nam lunae lux resilit, in nostra maria, cum luna est apud antipodas? In noviluniis, ait, quia refrigerato aere, internus maris calor, se se colligens, valentior factus, plures facit vapores et emittit. Sed si a superposito mari prohibiti egressu ipsorum attollunt, quo modo eos emittit? Et si emittit, quo modo egressu prohibentur, et attollunt? In lunae quadratis, addit, non multa a luna resiliente luce, nec proprio maris calore in se collecto, minime attollitur. At cur non saltem dimidio attollitur, ut et lux ei est dimidiata a plenilunio? Et calore dimidiate in se collecto? Hae fluxus ei viro causae funi. Refluxus vero hae aliae.”

⁶⁵ Galilei, *Dialogues*, 420. Cf. Galilei, EN VII, 446: “A quelli del calor temperato, potente a far rigonfiar l'acqua, dite che pongano il fuoco sotto di una caldaia piena d'acqua, e che vi tengan dentro la man destra sin che l'acqua per il caldo si sollevi un sol dito, e poi la cavino, e scrivano del rigonfiamento del mare.”

⁶⁶ Ibid., f. 141r(b): “Si Luna, uti aiunt, dux aquarum esset omnes aquas aequae duceret, non aliter ac igni, omnia comburitur ustilia. Sol omnes discutit tenebras, Luna ipsa omnia maria, omnes lacus, stagna omnia, amnes omnes, quando lucet, suo collustrat lumine, at non omnes ducit aquas. Non est erto aquarum omnium dux, non tractrix omnium, non avectrix.”

such as marine motions, for which it is necessary to identify the particular causes (*causae propriae*).

What then is the cause of the motion of the seas? Patrizi identifies it as an internal and vital impulse. In the same way in which the stars move about the ethereal heavens thanks to an autonomous impetus, like the birds in air and the fishes in water, the waters of our globe are moved by an intrinsic principle of life and movement.

Why should we not allot this to the inner nature of the sea? In fact, just as we have taught that the stars are carried through the ether by their intellect, soul and spirit, and that the planets, the Sun and the Moon, as well as the air below them, are carried by the same causes, in the same manner, why should it be a miracle that the sea is carried by its own nature in various directions not differently than the planets? Among those motions are the ebb and flow, [produced] by its own intellect, soul and spirit.⁶⁷

According to Patrizi, the Moon and Sun “impress” a motion on the waters but this relationship is not causal. Rather it is an approximate specularity: the sea or the ocean mimics the celestial motions “but in its own way” (*sed suo modo*). The vital motion of the waters is precisely the *mimesis* and *variatio* of those of the Sun and the Moon.⁶⁸ The impulse to life implies the search for self-preservation. The tide is a kind of breathing of the living sea that is nourished by an alternating generative exchange with the shores:

If we only consider the ebb, which we have attentively observed on so many shores, the issue does not seem to be deprived of reason. In fact, by calm sea, [the water] shows a motion forth and back to and from the plane shore, at regular intervals, producing a continuous motion, which we have called a sort of respiration. While part [of the waters] moves back and flows down into lower places, another part arises, merges, passes over it and covers the shore. The first [wave], as if it grew shy and sought its own safety, hides itself in the belly [of the sea], impregnates itself and

⁶⁷ Ibid., f. 142r(b): “Sed quid vetat maris propriae naturae hoc tribuere? Nam sicuti stellas propria natura, ab intellectu, ab animo, a spiritu, in aethere ferti docuimus, planetas quoque eisdem causis ferti, solemque lunamque, et sub eis aerem, quid miraculi est, mare, quoque pluribus natura sua, non aliter, ac planetae motibus cieri? Inter quos et affluxus sit, et refluxus? Ab intellectu nimirum, ab animo, a spirito suo.”

⁶⁸ Ibid., f. 142v(b): “A Luna ergo, et a sole in mare astrorum motus veluti imprimuntur, tum eorum quae perpetuo, uniformique circumeunt mundum motu, tum eorum, quae variis multiplicibusque feruntur; qualibus, et maria feruntur, et Oceanus. Sed suo modo. Nam illos quidem non assequitur, sed aemulatur. [...] Inesse autem plures salsedini spiritus, multa docent experimenta.”

grows. Once it has grown, it flows quicker to the shore. Thus, at regular intervals, a flowing forth and back is produced.⁶⁹

The origin of this phenomenon is a process of rarefaction and boiling similar to the process of thermal expansion advanced by Telesio. The heating of the waters results from the combination of the heat proper to them and the life-giving action of the Sun, Moon and stars.⁷⁰ The *causa propriissima* (the most direct cause), however, is an intimate impulse generated by the spirit inherent in the waters and concentrated in the salt. “Many experiences show that there are several spirits in that which is salty.”⁷¹ Hence the salt is the direct cause of the sea’s motions and the phenomenon of the tides in particular:

Saltiness – a nature that [the sea] does not share with any other [element] – is the most direct cause [*propriissima causa*] accounting for the variety of motions of the sea. In fact, no sweet water or water with another taste is moved in so many ways. Except for the salty, none has a flow and ebb [...]. Saltiness is therefore the closest, internal and most direct cause of the marine motions.⁷²

On this basis, Patrizi is able to indicate a cause intrinsic to the waters which accounts for the phenomenon of waves and tides. At the same time he does not reject the importance of celestial causes acting *in universale* rather than *in particulare*. Indeed he proposes a vitalistic and thermal theory able to hold together and go beyond the astrological theories and the heliothermal ones. Concerning the link between marine phenomena and astronomy, Patrizi’s perspective allows the abandonment of astrological causality without losing sight of the cosmological framework:

⁶⁹ Ibid., f. 143v(b): “Nam si modus refluxus consideretur, quem nos in multis littoribus studiose spectavimus, non videbitur quaestio carere ratione. Namque tranquillo mari, moto eo, quem perpetuam quasi eius respirationem appellavimus, continue, et fluere, et refluere ad plana littora, tempore eodem conspicitur. Parti enim eius recurrenti, et ad humiliora refluenti, pars alia altior supervenit, et priorem illam obruit, eique superequitat, et super eam in littus currit. Illa, quasi timida, salutem sibi quaerens, in ventrem se obruentis, conditur; et se ipsa gravidam eam reddit, et altiolem facit. Haec altior facta, citatior ad littora affluit. Eodem igitur tempore, affluxus fit et refluxus.”

⁷⁰ Ibid., f. 144r(a): “Dum vero bulliunt, et attolluntur, necessario rarescunt. Per ergo rarefactionem, quae attolluntur aquae, altiores se ipsis fiunt. Rarefactio autem, non nisi vacui atomis, quae omni (uti ostensum antea est) insunt aquae dilatatis, et maiorius redditus. A calorem nimirum in vapores partes aquae soluta. Eodem hoc modo (nullum enim alium experientia ostendit ulla) necesse est mare intumescere, ob poros eius rarefactos, et in vapores aquae parte acta, ab insito maris calore, a Sole interdium, a Luna etiam noctu, sideribusque concalefacto.”

⁷¹ Ibid., f. 142v(b): “Inesse autem plures salsedini spiritus, multa docent experimenta.”

⁷² Ibid., f. 142v(a): “Salsedo igitur propriissima est causa, nulli alii communis natura, cur mare tot motibus agitetur, nulla enim dulcis, nulla alterius saporis aqua, tot agitur; nulla affluxum, et refluxum [...] patitur, praeter unam salsam. Salsitudo ergo motum marinorum proxima, et interna, et propriissima est causa.”

Through these motions the sea, which is like a terrestrial ether, imitates the motion of the ethereal stars.⁷³

7. Concluding note

Telesio's tidal theory in *De mari* x-xiii is part of an extremely varied Renaissance discussion of the phenomenon. On the one hand, geographical explorations, colonial enterprises and the needs of navigation expanded and diversified knowledge of the seas and oceans, ocean currents, straits and tides. On the other hand, attempts at rational-empirical emancipation from astrology, increasingly seen as an occult, superstitious and dubious doctrine from both the theoretical and ethical point of view, coincided with the search for new explanations of the tides, whose theory appeared to be refuted by some of the commonest astrological explanations. Particularly influential was the discussion by Albumasar, whose *Introductorium in astronomiam* contained pages and pages on the influence of the Moon on the waters. The astrological treatise, a standard reference on the phenomenon in question, also dwelt on the exact relationship between the tidal cycle and lunar phases and on the variations of tides in relation to the changing positions of the Sun and Moon. After Newton, it would be understood that the basis of these correspondences between celestial motions and the tidal cycle was to be found in the law of universal gravitation, but for Albumasar's successors it was an astral influence. Indeed the celestial origin of the sea's motions was an indisputable empirical proof of the action of the stars on earthly events. In fact the origin of the explanation of the tides through the remote action of the Sun and Moon was astrological. In contrast, the philosophical, religious and ethical criticism of astrology also included rejection of the lunar or solar-lunar tidal theory and it was faced with the challenge of indicating an alternative explanation of the tides. A clear testament to the link between criticism of the lunar theory and the rejection of astrology is Pico's *Disputationes*, which had a broad influence on the scientific rationalism of the Renaissance.

Although the theory of remote attraction of the Moon and Sun continued to be followed throughout the 16th and 17th centuries, especially in university circles linked to Aristotelianism, there was a growing number of those subjecting this concept to severe criticism for the reasons just mentioned. Many scholars rejected the possibility of a remote action by means of a *cognata virtus* (as the interpreters of Albumasar called it), viewed as a *qualitas occulta* (in the terminology of the detractors). Very diverse natural philosophers and

⁷³ Ibid.: "Per hos motus, mare, quasi terrenus quidam aether, aethereos stellarum imitatur motus."

mathematicians, such as Giordano Bruno, Andrea Cesalpino and Galileo Galilei, completely denied the possibility of a lunar influence. For them, one could speak in the best of cases of a parallelism whose reasons were to be sought in a common root of the phenomena and not in a direct causality of one with respect to the other. The complete renunciation of celestial causes led either to vitalistic explanations by which the seas are moved by an intimate vital impulse or to a mechanical explanation.

Other Renaissance authors tried to take a middle way. They accepted Pico's invitation to limit the action of the heavenly bodies to motion, light and heat. For them, heat, not so much the lunar heat as the solar one, would be the cause (or a contributing cause) of waves and tides. This was the path taken not only by Bernardino Telesio but also by lesser-known thinkers such as the eclectic atomist Pandolfo Sfondrati.

In summary, four explanatory models of the tides merit our consideration.

1. The astrological approach in which the lunar, or lunar-solar, tidal theory makes use of the analogy of the magnet. The Moon is a kind of movable pole that attracts water to itself. This idea remained firm in the scholastic and Aristotelian tradition, as shown by its longevity among scholars of the University of Padua.

2. Vitalistic explanations such as those of Bruno and Patrizi. If we wish to indicate a metaphor for this option, it will be that of the living organism whose movements are conceived as teleological impulses aimed at self-preservation. In this perspective, Patrizi considers the tides as a motion of breathing by the living sea whose movement mimics "in its own way" that of the heavenly bodies, which are also free within the heavens. It is curious to note that although Patrizi rejects Telesio's heliothermal tidal theory he retains a thermal explanation of the tides and ultimately bases his explanation on Telesian premises, in particular the assumption that the sea is intrinsically warm, thus apt to move, and that its motions respond to a principle of universal animation.

3. The mechanical explanations of those who consider the motion of the tides analogous to the oscillation of a balance scale or to the behaviour of a vessel in movement which communicates its motion to the liquid it contains.

4. The heliothermal explanation seeks to rationalize the celestial influence by reducing it to a heating action. The metaphor is that of the boiling of a liquid in a pot.

Within the pluralism of positions expressed in the Renaissance debate on the tides and in the variety of explanatory models (sometimes intertwined and not always clearly distinguishable from one another), the explanation closest to the modern one is that with an astrological foundation. However it has several limitations with respect to Newton's

conclusions. For example, the remote action of the Moon is not conceived in terms of gravitational attraction. It is irreducibly qualitative. Indeed the *cognatio* of Moon and waters is qualitative; hence the *virtus tractorix* (tractive force) of the heavenly body is ascribed to an obscure essential affinity. Similarly the combined influence of the Moon and the Sun is expressed in astrological terms such as conjunction, quadrature and opposition. As mentioned above, the Renaissance detractors of this approach were worried not only about the elusive nature of the recourse to occult powers and remote actions but also about the ethical implications inherent in the assumption that the heavenly bodies do not act only on the elements but also on human events and choices.

Johannes Kepler, who did not disdain astrology at all, was harshly rebuked by Galileo for his acceptance of the lunar theory of the tides:

“But among all the great men who have philosophized about this remarkable effect, I am more astonished at Kepler than at any other. Despite his open and acute mind, and though he has at his fingertips the motions attributed to the earth, he has nevertheless lent his ear and his assent to the moon’s dominion over the waters, to occult properties, and to such puerilities.”⁷⁴

In truth, Kepler opened the way to modern celestial physics by laying the foundation for Newton’s explanation. With all due respect to Galileo, it is no coincidence that a supporter of the Copernican system with astrological interests had to be the intermediary between the lunar theory of the tides and the modern gravitational explanation. In fact the heliocentric theory demolished the idea of the uniqueness of the centre of gravity of the universe of Aristotelian physics and forced scholars to admit that there are many centres of gravity in the universe. This is an indispensable assumption for a theory of universal gravitation.

The Renaissance debates on the tides remind us that the historical developments of empirical and rational science travelled along roads that were anything but straight. The plurality of opinions and theories about the tides presents an inextricable tangle of philosophical, ethical and methodological views in which the link between scientific theories, rationality and experience is extremely complex. Telesio’s discussion in *De mari* fits precisely in the core of a debate in which both the precursors of modern scientific rationality

⁷⁴ Galilei, *Dialogues*, 462. Cf. Galilei, EN VII, 486: “Ma tra tutti gli uomini grandi che sopra tal mirabile effetto di natura hanno filosofato, più mi meraviglio del Keplero che di altri, il quale, d’ingegno libero ed auto, e che aveva in mano i moti attribuiti alla Terra, abbia poi dato orecchio ed assenso a predomini della Luna sopra l’acqua, ed a proprietà occulte e simili fanciullezze.”

and the discredited heirs of doctrines destined to marginalization and decline, such as astrology, contributed to the discovery of the fundamental laws of nature.

This essay is an outcome of a project that has received funding from the European Union's Horizon 2020 Research and Innovation Programme (GA n. 725883 EarlyModernCosmology)

