Codex Ambrosianus no. 334
De Fluxu et Refluxu Maris : Concerning the flood and ebb tides
De diuersis motibus aquae maris opiniones : Ideas about the tides
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PREFACE (cod. f. 1 r)

Aristotle states (*Meteorology – Book I*) that "we believe that we can give a rational explanation of those things our senses perceive when we have reduced them to a natural law".

I have conceived the idea of examining the various movements relating to the flood and ebb tides of the sea and at the same time explaining some of the probable causes of these phenomena.

Galen states (*"Critical Days" - De diebus decretoriis*) that whatever is good and beautiful, and also things that follow a unique order, proceed from heaven above; in the same way I will base my deductions on the influence of Celestial Bodies.

This thesis is also supported by Aristotle, who (Meteorology – Prologue) writes : So that all movement is consistent it is necessary that our lower world be regulated by Higher Powers

For Albumasar (Abù Ma'shar, *Introduction to Astronomy – 3rd Difference*) there are two primary motions: a) the circular one b) the straight one.

While the Celestial Bodies can have only a single, perfect (circular) motion, Earthly Bodies can have two kinds of motions: along a straight line, which is the most common to elements, and a revolution, the latter being characteristic of imperfect things, which can be generated and are corruptible, and therefore are ruled by the upper circular movement, which is perfect.

It is then evident that the tides are ruled by the Forces of the Celestial Bodies. Of these, the Sun and the Moon are the principal ones, which predominate and most influence the movement of the lower bodies.

THE SUN - It is found to be the largest of the stars, including the Earth. According to Ptolemy it is 167 times bigger than the Earth; its power is the most noticeable, as we see also in the plants which follow the movement of the Sun. We see an example in the trees, the grasses and especially in the most flexible flowers (cod. f. 1v).

THE MOON - It is found to be smaller than the other Bodies and even the Earth, with the exception of Mercury; but it has a strong influence on the movement of liquids on account of its proximity and the speed of its movement.

Aristotle (*Generation of Animals – Book IV, last chapter*) states that the Moon controls waters. The Moon, therefore, is like another Sun, since it also influences the generation and changes of all living things.

The different movement of the Upper Bodies, above all of the Sun and Moon, and their varying position and distance, generate and influence various movements in the lower world and its coastal waters.

I, with the inspiration and the help of God, have decided to write the present treatise, which is divided into 4 chapters.

CHAPTER I

On the various movements of the water of the sea.

1st Proposition.

The sea has :

- the flood, or rising tide => once a day and once a night.
- The ebb, or falling tide => once a day and once a night.

2nd Proposition

The flood or rising tide does not always begin at the same time of day and night, but at varying times.

A similar variation happens also for the ebb or falling tide.

3rd Proposition

There are periods during which there is no order :

- in flood or rising tide
- and in ebb or falling tide

4th Proposition

The tidal flow:

- is sometimes at its maximum
- is sometimes at its minimum

- is sometimes intermediate

5th Proposition

Low water is sometimes maximal and sometimes minimal.

Similarly, high water is at times maximal and other times minimal.

And sometimes it has an intermediate value.

6th Proposition

The tidal range is sometimes greater than usual (cod. f. 2 r).

CHAPTER II

Postulates necessary to deduce an explanation of the Propositions on the tides.

1st Postulate

The movements of the Sun and Moon in various regions of the sky and the movements of the firmament generate the flood and ebb of the tide.

2nd Postulate

The natural day (i.e. from noon to noon) is divided into 4 Quarters, of which there are:

2 during the day - 2 during the night

3rd Postulate

The 1st daytime Quarter (sunrise-noon) is called the Daytime Flood Tide Quarter.

The presence of the Sun and Moon causes the flood tide.

The 2nd daytime Quarter (noon-sunset) is called the Daytime Ebb Tide Quarter.

The presence of the Sun and Moon causes the ebb tide.

The 1st night-time Quarter (sunset-midnight) is called the Night-time Flood Tide Quarter.

The 2nd night-time Quarter (midnight-sunrise) is called the Night-time Ebb Tide Quarter.

4th Postulate

In the natural day there are 4 times at which one observes a lower strength in the flow of the water, namely:

- noon and midnight => lower force in generating the ebb tide.
- sunrise and sunset => lower force in generating the flood tide.

5th Postulate

In the natural day there are 4 times at which one observes a greater strength, namely:

- two for the flood tide:
  the middle point between sunrise and noon,
  the middle point between sunset and midnight.
- Two for the ebb tide:
  the middle point between noon and sunset,
  the middle point between midnight and sunrise.

6th postulate (cod. f. 2 v)
The points in the sky other than the eight mentioned above will influence the ebb and flow of the water more when they are nearer to a point of maximum strength.
And the closer they are to a point of minimum strength, the less they will influence the flow.

7th Postulate
Each of the points at equal intervals from the 4 principal points

Sunrise, Sunset, Midday, Midnight

will exert an equal force on the movement of the tides.
Everything is shown in Fig. 1 on the following page.

CHAPTER III

The possible causes of the various movements of the sea.

Explanation of the First Proposition

It has been stated that in a natural day there is a double movement of the tides.
In fact one has two flood tides and two ebb tides.

The Sun and the Moon, both causing movement as stated in the 1st Proposition, over the length of a natural day are twice in a Flood Tide Quarter, i.e. once during the day and once during the night.
Therefore, as stated in the 3rd Postulate, in a natural day the water will flow in twice:

- once by day
- once by night

Hence over the span of one day and one night the water moves 4 times:

- twice by day => a flood tide and an ebb tide
- twice by night => a flood tide and an ebb tide.

Explanation of the Second and Third Proposition

It was stated in the first chapter that the flood tide does not always occur (cod. f. 3 r) at the same time of the day and night; the same is true for the ebb tide.
We have also seen in the 3rd Proposition that sometimes the flow of the flood and the ebb tides occurs without any order.

To clarify this phenomenon I shall first describe in general the diversity of tidal movement, and then I shall make the details clearer.

For the moment I state that the changes in the tides are above all due to the influence of the Sun and Moon, depending on their relative positions:

Fig. 2

a) - The Moon is in conjunction with the Sun

The water begins to rise at sunrise or sunset. Then it begins to fall at noon or at midnight. The water flow is very fast, and the rise during the flood tide and the fall during the ebb tide are also quite rapid.

b) – The Moon is in opposition to the Sun.

We see it perfectly round at full moon.

The water comes in and out in an ordered way and at the predicted times, just as happens when the Sun and Moon are in conjunction.

The flow is at a maximum, with maximum rise and fall.

It should be noted that, in comparison to conjunction, in this phase the tidal ranges are greater, as we shall see later on in the explanation of Proposition 6.

c) – The Moon is at Quadrature with the Sun

We see it half-illuminated.

The flood and ebb tides do not occur at predictable times and there are also minimum water flows and minimum tidal ranges.

In the Venetian language, this phase is called “Fele”.

d) – The Moon is in an intermediate position between the main celestial points.

The Sun and Moon find themselves at points of equal strength. The water begins to flow in or out when until the Sun and Moon are at a point which causes the flow inversion.

The closer the Moon approaches conjunction with or opposition to the Sun, (cod. f. 3v) the greater will be the tidal flow. In the same way the tidal range will be less as the Moon approaches Quadrature.

Fig. 2 helps in understanding what has been said and what will come.

From these general premises, coming back to the subject, I shall state that the flood and ebb tides of the sea are not always repeated in the same way or at the same times, for - as we shall see – they are related to the remoteness (=distance) of the Moon from, or its proximity to, the Sun. In fact the Moon can be:

in Conjunction, in Opposition, at Quadrature, in intermediate positions.

****** The Moon is in Conjunction with the Sun**

We have a new Moon, at the beginning of the lunar cycle.

As has been said:

A) – the flood tide begins either at sunrise, or at sunset.

f [1]) – Daytime flood tide. The water starts to rise at the beginning of the day, as the Sun rises, because it enters the daytime flood Quarter.

Also the Moon, - which is in conjunction with the Sun, will enter the aforesaid Quarter.

Both are the cause of tides and – at sunrise – both are aligned (at the same time and position). They begin to enter the daytime flood Quarter together. Hence the daytime flood tide begins when the Sun is rising.

f [2]) – Night-time flood tide. It is clear that for the same reason and in the same way the night-time flood tide begins (cod. f. 4r) at sunset, i.e. at the beginning of the night. In fact, when the Sun is setting, the Sun and Moon enter the night-time flood Quarter together.

B) – the ebb tide begins at noon and also at midnight.

r [1]) – Daytime ebb tide. The ebb tide begins when the Sun is at noon. At the same time, the Moon and Sun are entering the daytime ebb Quarter; and the ebb tide begins.

r [2]) – Night-time ebb tide. The ebb tide begins at midnight, because the Sun and the Moon are entering the night-time ebb Quarter together.

******** **The Moon is in Opposition to the Sun.**

We are at full Moon.

As at Conjunction, the flood and ebb tides begin at a predictable time.

f [1]) – Daytime flood tide. The daytime flood tide begins at sunrise, since the Sun is entering the daytime flood tide Quarter and the Moon, which is opposed to the Sun, is entering the night-time flood tide Quarter at the same time.

Hence: with the Sun in the East and the Moon in the West we have the beginning of the daytime flood tide.

f [2]) – Night-time flood tide. The night-time flood tide starts at the beginning of the night, when the Sun is in the West. In fact the Sun enters the night-time flood tide Quarter and the Moon, which is opposed to the Sun, enters the daytime flood tide Quarter.

Hence: with the Sun in the West and the Moon in the East the night-time flood tide begins.

r [1]) – Daytime ebb tide. The beginning of the daytime ebb tide will be at midday, since the Sun enters the daytime ebb tide Quarter and the Moon, at the same time, enters the night-time ebb tide Quarter. Hence one has the beginning of daytime ebb tide. (cod. f. 4 v)

r [2]) – Night-time ebb tide. Similarly, the beginning of the night-time ebb tide occurs at midnight. In fact the Sun enters the night-time ebb tide Quarter at the same time as the Moon enters the daytime ebb tide Quarter. Hence the beginning of the night-time ebb tide will be at midnight.

From what we have said we infer that:

- the water starts to flow in => at the beginning of the day or at the beginning of the night
- the water starts to flow back => at noon or at midnight.

It is now clear when this happens and also why it happens:

- either when the Moon is in conjunction with the Sun, that is at New Moon
- or when the Moon is in opposition to the Sun, that is at Full Moon.

(special) Explanation of Proposition 3

( ) *Causes of the slack water that the Venetians define as "fele"*

****** The Moon is in Quadrature with the Sun**

We see the Moon half-illuminated.

The water does not follow a precise rule for flood and ebb tides and moves, at shorter intervals, in an irregular way. We have an anomalous rise and likewise an anomalous fall.

The cause of such tidal irregularity is due to the positions of Sun and Moon, since their forces have an opposite action on the movement of the water.

To understand this one has to say that the Moon, as seen from the Earth, finds itself at Quadrature with the Sun twice in each monthly cycle (New moon to New moon).

- the first time in the waxing phase. After conjunction, the Moon is at a distance of a quarter of the sky from the Sun. This happens after seven days.
- The second time in the waning phase. After full Moon, the Moon approaches the Sun by another Quarter of the sky, coming to Quadrature with the Sun. And that happens roughly 22 days after New Moon.

At each Quadrature the Moon appears half-lit. (cod. f. 5r)

All this is well shown in the figure inserted in this chapter.

The Moon is at First Quadrature with the Sun.
It is waxing and lagging the Sun.

When the Sun is rising, i.e. at the beginning of the daytime flood tide, the Moon is a quarter part of the sky behind the Sun and it will be at exactly the midnight position, where it normally causes a night-time ebb tide.

In these two Quarter parts of the sky the forces are opposing, hence:

- the Sun, which enters daytime flood tide Quarter, causes a flood tide.
- The Moon, which enters the night-time ebb tide Quarter, should cause an ebb tide.

Hence one sees that the water does not flow in, or out, in a regular and complete way. And the same happens if the Sun is at any other point, because the Moon will always be in a position where its action is opposed to that of the Sun.

Hence one will have,

the Sun at:

East Noon West Midnight

the Moon is at:

Midnight East Noon West

The forces at these points are all opposing, as we have seen in the postulates.

Wherever in the sky the Sun may be, the anomaly will be repeated, since the Moon will always be in a position where its force is opposing.

The Moon is at Second Quadrature with the Sun.

It is waning and leads the Sun.

We have the same anomaly as above because, in whatever part of the sky the Moon and Sun may be, their positions are a source of opposing forces.

For instance: should the Sun be at the eastern point, since the Moon precedes the Sun, it will be at the midday position and the influence of these two points is mutually opposed, as we have said (cod. f. 5 v).

At this Quadrature one has:

The Sun at:

East Noon West Midnight

the Moon is at:

Noon West Midnight East

The forces at all these points are mutually opposing, as we have seen.

Therefore, when the Sun and the Moon are a Quarter part of the sky apart we have:

- the Sun causes the flood (or the ebb) of the tide
- the Moon causes the ebb (or the flood) of the tide

with the result that their action on the sea cancels out.

As a consequence, as seen in the 3rd Proposition, the water rises or falls without any order:

- either with reference to the time
- or with reference to the amplitude of the tide.

And the flood and ebb levels, as well as the tidal flows, will be minimal, as we will see in the 4th and 5th Proposition.

The Venetian sailors call this kind of flow "fele"*, which is to say* "fedele" *(faithful), because the tide rises moderately, falls moderately, and causes a moderate flow at both flood and ebb tides.*

****** The Moon is at a point different from the main positions in the sky.**

The Moon is not at one of the main celestial points, that is:

neither in conjunction,
nor in opposition,
nor at Quadrature with the Sun.

The further the Moon is from Conjunction with or Opposition to the Sun the more the starting times of the flood and ebb tides will change.

The tide will begin when the Sun and the Moon are at positions in the sky which exert an equal force, or if the two bodies are (cod. f. 6r) in Quarters of opposing forces, that is if the Sun is in a flood-tide Quarter and the Moon is at a point of equal force in an ebb tide Quarter, or the other way round.

Points of equal force are those having an equal distance from the 4 main positions, which are the East, West, midday and midnight points as we have seen in the 7th Postulate.

If the Moon is in one of these points, it can be:

*1 => between conjunction and first Quadrature

*2 => between first Quadrature and opposition

*3 => between opposition and second Quadrature

*4 => between second Quadrature and conjunction

***1 The Moon is between conjunction and first Quadrature.**

The Moon follows the rising Sun.

1.1 – The daytime flood tide begins in the East, after Sunrise and around the third hour or slightly earlier, when the Sun is as much above the eastern horizon as the Moon is below the same eastern horizon. The Sun and the Moon are then at points of equal influence, according to the 7th Postulate.

1.2 – The night-time flood tide begins in the West by night, after sunset, when the Sun is as much below the western horizon as the Moon is above it.

1.3 – The daytime ebb tide begins after noon, when the Sun has gone past the mid-day point and the Moon has not yet reached that point

1.4 - The night-time ebb tide begins after midnight, when the Sun has gone past that point and the moon is approaching it.

***2 The Moon is between the first Quadrature and Opposition to the Sun.**

The Moon lags behind the rising Sun (cod. f. 6v).

2.1 – The daytime flood tide begins in the West, after noon, or slightly before or slightly after sunset, when the Sun is as high above the western horizon as the moon is high above the eastern horizon. These are equal strength positions, as mentioned in the 7th Postulate.

2.2 – The night-time flood tide begins in the East, before daylight, when the Sun is as much below the eastern horizon as the Moon is below the western horizon.

2.3 – The daytime ebb tide begins before midday, when the Sun is as far before the midday point as the Moon is after the midnight point.

2.4 – The night-time ebb tide begins before midnight, i.e. when the Sun is as much before the midnight position as the Moon is after the midday point.

These two points have equal strength, as we infer from the 7th postulate.

***3 The Moon is between Opposition and second Quadrature.**

The Moon precedes the sunrise.

The two phases, of flood and ebb tides, begin in the same way as has been described for the Moon between Conjunction and first Quadrature.

3.1 – The beginning of the Eastern daytime flood is in the morning, towards the third hour or slightly earlier, when the Sun is as far above the eastern horizon as the Moon is above the western horizon.

3.2 – The night-time flood tide begins in the West and in the evening, when the Sun is as far below the western horizon as the Moon is below the eastern horizon.

3.3 – The daytime ebb tide begins after midday, when the Sun is as far away from the midday point as the Moon is before the midnight point.

3.4 – The night-time ebb tide begins after midnight, when the Sun is as far away from the midnight point as the Moon is before the midday point.

***4 The Moon is between second Quadrature and Conjunction with the Sun.**

The Moon precedes sunrise.

The flood and ebb tides begin in the same way as when the moon is between the first Quadrature and conjunction.

4.1 – The daytime flood tide begins in the West around or after twilight, when the Sun will be above the western horizon by as much as the Moon will be below the same horizon.

4.2 – The beginning of the night-time flood tide will be in the East, before dawn, about the time of morning prayer**,** when the Sun is as much below the eastern horizon as the Moon is above it.

4.3 – The day-time ebb tide begins before midday, when the Moon is as much beyond the midday point as the Sun is before the same point.

4.4 – The night-time ebb tide begins before midnight, when the Moon is as much beyond the midnight point as the Sun is before the same point.

From what we have said, we get confirmation of the statement of the second proposition, i.e. that the flood and ebb tides do not always begin at the same times. As a matter of fact:

- the beginning of the flood tide comes:

  either at the beginning of the day

  or at the beginning of the night.

  This happens when the Moon is in conjunction or in opposition.

But it can also begin:

  before sunrise, from morning prayer until dawn,

  or in the day time, up until the third hour (cod. f. 7v)

  or before night, from twilight until nightfall

  or by night, until the cock crows.

This happens when the Moon is between a Quadrature position and either in conjunction with or in opposition to the Sun.

- The ebb tide begins

  either at midday

  or at midnight

  This happens when the Moon is between conjunction with or opposition to the Sun and in one of the Quadrature positions.

But it can come:

either before or after midday

or before or after midnight

This happens also when the Moon is between Conjunction, or Opposition to the Sun, and a Quadrature position.

When the Moon is in Quadrature with the Sun, that is when we see it half-lit, the tide does not show a precise beginning or order in its flood and ebb.

Thus the statement of the 3rd Proposition is proved.

Note that:

- for the flood tide we refer to the eastern or western horizon
- for the ebb tide we refer to the midday or midnight point.

Note also that what has been said applies to the equinoctial horizon (= equator), since for an oblique horizon (= at any other terrestrial latitude) one may have other and irregular times, as we shall see further on.

Explanation of the 4th Proposition

Maximum, minimum and intermediate tidal flows.

The tidal flow appears to be sometimes maximum, sometimes minimum and at other times intermediate.

There is the strongest flow when the Moon and the Sun are in conjunction, i.e. at new Moon, or in Opposition, i.e. at full Moon (cod. F. 8r).

As we have discussed in the 3rd Proposition, when the Sun and Moon are in conjunction, both forces cause the tide, i.e. the Sun and Moon, act together. For this reason one has a strong flow, because both Bodies combine to cause a flood and then an ebb tide.

Similarly, the flows and tides are strongest when the moon is in Opposition to the Sun.

This happens even if the two forces moving the water, i.e. the Sun and Moon, are not exactly in conjunction or exactly opposed. Thus, if the Sun and Moon are in the same quarter of the sky they act upon the tides with the same strength, as we have seen from the 2nd Proposition.

The Sun and Moon at a given time exert the same influence. Hence if the Sun causes a flood tide, the Moon will do the same at the very same time. Similarly, if the Sun should cause an ebb tide, the Moon will do so at the same moment.

One will have the strongest flows when both forces act together at the same time to cause an equal tidal flow, be it flood or ebb tide.

We will have the weakest tidal flow when the Moon is at one of the two positions of Quadrature with the Sun, and we see it half lit.

We have seen that at a Sun-Moon conjunction or opposition their forces act at the same time and in the same way; on the contrary when the Moon is in a Quadrature position, the forces of Sun and Moon oppose each other in a given action; we have

explained in the 2nd Proposition the effects on the sea when the Moon (cod. f. 8 v) is in Quadrature with the Sun.

When the influences of the sun and moon on the tide oppose one another one will have minimum tidal flow. When that happens, the Venetians call this particular water state "Fele".

Sometimes one will have intermediate flow speeds, neither maximal nor minimal. In this case the Moon, with respect to the Sun, is at any point other than the 4 positions: Conjunction, Opposition, 1st Quadrature or 2nd Quadrature.

At these times the forces of the Sun and Moon do not act on the tide fully together or fully opposed.

The flow becomes stronger as the Moon approaches Conjunction or Opposition to the Sun, and diminishes as it approaches a Quadrature point.

Explanation of Proposition 5

The tidal fall is sometimes maximum, sometimes minimum.

The tidal rise is sometimes maximum, sometimes minimum.

And sometimes it has intermediate values.

x – The tidal fall or rise is greatest when the Moon is in conjunction with or opposition to the Sun. As we have said, this happens because the Sun and Moon act together to maximize the flow of water

If the force acts during the ebb tide, the fall will be maximum.

If the force acts during the flood tide, the rise will be maximum.

The flood and ebb flows will also be the strongest at the same time

To a maximum fall corresponds (cod. f. 9 r) a maximum rise.

x – Sometimes the rise and fall are minimum. This happens when the Moon is in a Quadrature position, the actions of the Sun and Moon are mutually opposed and the flood or ebb flow is weaker.

The tidal rise and fall will also be minimum, as happens in the tidal condition which the Venetians call "fele".

x – The tidal rise and fall are sometimes moderate; this happens when the Moon is in any position other than the main four, which are Conjunction, Opposition, first or second Quadrature; as has been said the flood or ebb flow has a medium value.

This explains an intermediate rise and fall.

Explanation of the 6th (last) Proposition

The tidal rise is sometimes exceptionally high.

As said before in this chapter, when the Moon is in conjunction with or opposition to the Sun the tidal range is maximal. But it is not always the same. In fact, it is

larger at full moon, when the Moon is in opposition to the Sun, than when the Moon is dark because of conjunction.

One can explain this in agreement with Aristotle (*De generatione et corruptione - On generation and destruction*): the Upper Celestial Bodies transmit their force to the lower Bodies through their movement and light.

The more the light, the greater the influence.

The Moon exerts a considerable force on the water; hence the brighter it is, the more its light will influence the tides (cod. f. 9 v), as all the astrologers assert. And since we see more light at full Moon than in any other period, we infer that the tidal range is higher at opposition than at conjunction.

CHAPTER IV

The reasons for some anomalous tides,
or
The tide does not always proceed in a predictable way.

According to Aristotle (*Ethics – Book One*), discourses must be relevant to the matter under discussion.

The matter we are talking about is water, which is changeable and mutable and – unlike the celestial bodies, especially the most perfect ones, does not always follow its proper course. Since water is by its own nature the most imperfect of the elements, it often deviates considerably from its normal course, even if in many cases it moves as foreseen

Deviation and error, as has been stated, cause twofold changes of the tide:

- a variation on the beginning of the flood and ebb tides.
- A variation in the movement itself, i.e. flows can be faster or slower than normal, or the water rise and fall are larger or smaller than expected.

Changes of strength and time of the tide can be due to three reasons:

a) – the land geographical position
b) – the influence of upper celestial bodies
c) – meteorological changes

A) Geographical position

The geographical position causes some variation or error in the tide, which concerns only the time of the flood tide, which is related to the horizon (= latitude, cod. f. 10r). The beginning of the ebb tide, on the contrary, does not show any anomaly or variation, because it is related to the meridian, as explained in the 3rd Proposition.

Let us clarify.

Any region can be either on the equinox circle (= equator) or away from it, to a greater or lesser extent (= geographical parallels).

Lands on the equinoctial circle have an East-West aligned horizon; days last as long as nights in every season.

There in any season what we have described in the 2nd and 3rd Proposition, on the beginning of the tides is true.

Regions remote from the equinoctial circle have an oblique horizon and therefore, only twice a year will the flood tide begin as in the equinoctial territories:

- at the vernal equinox i.e. towards the middle of March
- at the autumnal equinox, i.e. around mid-September.

In other periods of the year the flood begins as follows:

1) – Period from :

the vernal equinox => SUMMER => until the autumn equinox.

The beginning of the tide will vary:

- if the daytime flood tide begins before midday, i.e. in the morning, it will be later with respect to the equinoctial regions. This is because in our countries the day begins before the equinoctial horizon sunrise, which is due East (= equator = East).
- If the daytime flood tide begins after midday, i.e. towards the evening, it is in advance of the equinoctial regions, where there are less daylight hours, since in our countries the Sun sets later than the equinoctial horizon sunset which is due West (cod. f. 10v).
- If the night-time flood tide begins before midnight, then in our regions and places it is in advance, since the length of the night is shorter than in equinoctial regions. In fact the night begins after the Sun touches the 'right' horizon, which is due West.
- If the night-time flood tide begins after midnight, towards dawn, it will be later because in the equinoctial regions the night lasts more hours. The Sun indeed rises earlier in our countries than at the East point of the 'right' horizon. The time difference can be so large, that sometimes one notices two flood tides over the day and none in the night, precisely because of the difference in length between the day and night. And the more the length of day and night differ, the greater will be the anomaly. This behaviour is evident in the longest days of the year.

2) – Period from

the autumnal Equinox => WINTER => until the Vernal Equinox.

It will be the opposite of the period examined above because:

- if the daytime flood tide begins before midday, in the morning, it will be in advance of the equatorial horizon, because of the few daylight hours. Indeed in our country the Sun will rise later than in the equinoctial regions.
- If the flood tide begins after midday, i.e. towards evening, the flood tide will be later than in the equinoctial regions (cod. f. 11r).
  Indeed, in our regions night falls before the Sun reaches the West point or 'right' horizon.
- if the night-time flood tide begins before midnight, then it comes later in the night than in equinoctial regions. This is because the night begins before the Sun touches the West point or 'right' horizon.

- In the night-time flood tide starts after midnight, towards dawn, the flood tide begins earlier in our country than on the equator. This is because the Sun rises later for us than at the 'right' horizon.
  The difference can become appreciable, sometimes there are two night-time flood tides and no daytime flood tide. That happens because of the unequal length of the day and night. The longer the night as compared to the day the greater the difference. In the longest nights of the year the difference will be most evident.

From what we have said it is appears that:

- the nearer we are to an equinox, the smaller the change of the beginning time of the flood-tide will be.

- the nearer we are to a solstice (summer or winter), with longer days or nights, the greater will be the variation and the more evident will be the difference.

B) – Influence of Celestial Bodies

The force of Upper Celestial Bodies causes not only a change in the time the flood tide begins but also that of the ebb tide. If any of the big and bright stars, e.g. Venus or Jupiter, is near to the Sun or Moon (cod. f. 11v) the tide is favoured, because of a supplementary force. That explains the variation in the tides

C) – Changes in the air

Changes in the air often cause irregularities in the time at which the flood and ebb tides begin. The presence of strong winds, nearby or remote, modifies the normal flood or ebb tides, sometimes accelerating them, sometimes delaying them

The variation in the tides happens also because the rise or fall of the tides do not always follow their normal order.

The wind direction can enhance strong or weaker flows, so that larger increases or decreases are noticeable.

D) – Narrows and straits

The presence of straits or inlets of the coast, due to the presence of islands or mountains at any coastal site, cause stronger flows.

Where the sea gets narrower, the flow is enhanced, as one can easily see in the Euripus channel near Euboea island or between Sicily and Calabria.

The straits can restrict the rise of the water; indeed, only a small quantity of water can flow through a strait. Hence the height of the flood tide can be reduced, as happens in practice.

The tides are greatest in the Ocean because nothing restrains or impedes the water flow – the tides there proceed with a guaranteed regularity – whereas (cod. f. 12r) in our Mediterranean Sea things are different, because the water coming in or out from the Ocean flows on its western side through a single passage which is narrow and difficult.

This is why the Our Sea cannot be filled to a large extent by the flood tide, nor can it empty very much during ebb tides. Therefore the tides do not act in a verifiable order.

These are, for **Jacopo de' Dondi, citizen of Padua**, the explanations which justify the changing behaviour of tides.

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The translation is the result of a joint collaboration of F. Soso, M.T. Wright, and on the account of the Fraternity of Friends of St Alban's Abbey, Sheila Green and Ch. Gail Thomas.