ſenſibly half an hour before the top of the tide, and quickly changes the height of the rod, ſo that we cannot make a great miſtake in the time.

Mr Bernoulli has made a very careful compariſon of the theory thus corrected, with the great collection of observations preſerved in the *Depot de la Marine* at Breſt and Rochefort@@\* ; and finds the coincidence very great, and far exceeding any rule which he had ever ſeen. Indeed we have no rules but what are purely empirical, or which ſuppoſe a uniform progreſſion of the tides.

The heights of the tides are much more affected by local circumſtances than the regular series of their times. The regular ſpring tide ſhould be to the neap tide in the ſame proportion in all places ; but nothing is more different than this proportion. In ſome places the ſpring tide is not double of the neap tide, and in other places it is more than quadruple. This prevented Bernoulli from attempting to fix the proportion of M to S by means of the heights of the tides. Newton had, however, done it by the tides at Briſtol, and made the lunar force almoſt five times greater than the ſolar force. But this was very ill-founded, for the reaſon now given.

Yet Bernoulli ſaw, that in all places the tides gradually decreaſed from the ſyzigies to the quadratures. He there­fore presumed, that they decreaſed by a ſimilar law with the theoretical tides, and has given a very ingenious method of accommodating the theory to any tides which may be obſerved. Let A be the ſpring tide, and B the neap tide in any place. Then form an M and an S from theſe, by M = (A + B)/2, and S = (A — B)/2 ; ſo that M + S may be = A, and M — S = B agreeable to theory. Then with this M and S compoſe the general tide T, agreeable to the conſtruction of the problem. We may be perſuaded that the reſult cannot be far from the truth. The following table is calculated for the three chief diſtances oſ the moon from the earth.

|  |  |  |  |
| --- | --- | --- | --- |
| Elong.  ſej *i=∖* | Height of the Tide. | | |
| Moon in Perigee. | Moon in Μ. Dist. | Moon in Apogee. |
| 0 | O,99A + 0,15B | 0,88A + 0,12B | 0,79A + 0,08B |
| **10** | 1,10A + 0,04B | 0,97A + 0,03B | 0,87A + 0,02B |
| 20 | 1,14A + 0,00B | 1,00A + 0,00B | 0,90A + 0,00B |
| 30 | 1,10A + 0,04B | 0,97A + 0,03B | 0,87A + 0,02B |
| 40 | 0,99 + 0,15B | 0,88A + 0,12B | 0,79A + 0,08B |
| 59 | 0,85A + 0,32B | 0,75A + 0,25B | 0,68A + 0,18B |
| 60 | 0,67A + 0,53B | 0,59A + 0,41B | 0,53A + 0,29B |
| 70 | 0,46A + 0,75B | 0,41A + 0,59B | 0,37A + 0,41B |
| 80 | 0,28A + 0,96B | 0,25A + 0,75B | 0,23A + 0,53B |
| 90 | 0,13A + 1,13B | 0,12A + 0,88B | 0,11A + 0,62B |
| **100** | 0,03A + 1,24B | 0,03A + 0,97B | 0,03A + 0,68B |
| **110** | 0,00A + 1,28 B | 0,00A + 1,00B | 0,00A +0,70B |
| 120 | 0,03A + 1,24B | 0,03 A + 0,97B | 0,03A + 0,68B |
| 130 | 0,13A + 1,13B | 0,12A + 0,88B | 0,11A + 0,62B |
| 140 | 0,28A + 0,96B | 0,25A + 0,75B | 0,23A + 0,53B |
| 150 | 0,46A + 0,75B | 0,41A + 0,59B | 0,37A + 0,41B |
| 160 | 0,67A + 0,53B | 0,59A + 0,41B | 0,53A + 0,29B |
| 170 | 0,85A + 0,32B | 0,75A + 0,25B | 0,68A + 0,18B  0,79A + 0,08B |
| 180 | 0,99A + 0,15B | 0,88A + 0,12B |

Obſerve that this table is corrected for the retardation ariſing from the inertia of the waters. Thus when the moon is 20 degrees from the ſun, the mean diſtance tide is 1,00A + 0,00B, which is the theoretical tide correſponding to conjunction or oppoſition.

We have now given in ſufficient detail the phenomena of the tides along the equator, when the ſun and moon are both in the equator, ſhewing both their times and their magnitude. When we recollect that all the sections of an oblong ſpheroid by a plane paſſing through an equatorial diameter are ellipſes, and that the compound tide is a com­bination of two such ſpheroids, we perceive that every section of it through the centre, and perpendicular to the plane in which the ſun and moon are ſituated, is alſo an ellipſe, whoſe ſhorter axis is the equatorial diameter of a ſpring tide. This is the greateſt depreſſion in all ſituations of the luminaries ; and the points of greateſt depreſſion are the lower poles of every compound tide. When the luminaries are in the equator, theſe lower poles coincide with the poles of the earth. The equator, therefore, of every compound tide is alſo an ellipſe ; the whole circumference of which is lower than any other fiction of this tide, and gives the place of low water in every part of the earth. In like manner, the fiction through the four poles, upper and lower, gives the place of high water. Theſe two sections are terreſtrial meridians or hour circles, when the luminaries are in the equator.

Hence it follows, that all that we have already ſaid as to the times of high and low water may be applied to every place on the surface of the earth, when the sun and moon are in the equator. But the heights of tide will diminiſh as we recede from the equator. The heights muſt be re­duced in the proportion of radius to the coſine of the lati­tude of the place. But in every other ſituation of the ſun and moon all the circumſtances vary exceedingly. It is very true, that the determination of the elevation of the waters in any place whatever is equally easy. The difficulty is, to exhibit for that place a connected view of the whole tide, with the hours of flood and ebb, and the difference between high and low water. This is not indeed difficult ; but the proceſs by the ordinary rules of ſpherical trigonometry is tedious. When the ſun and moon are not near conjunction or oppoſition, the ſhape of the ocean resembles a turnip, which is flat and not round in its broadeſt part. Before we can determine with precision the different phenomena in connection, we muſt aſcertain the poſition or attitude of this turnip ; marking on the surface of the earth both its elliptical equators. One of theſe is the plane paſſing thro’ the sun and moon, and the other is perpendicular to it, and marks the place of low water. And we muſt mark in like manner its firſt meridian, which passes through all the four poles, and marks on the surface of the earth the place of high water. The poſition of the greateſt fiction of this compound ſpheroid is frequently much inclined to the earth’s equator ; nay, ſometimes is at right angles to it, when the moon has the ſame right aſcenſion with the ſun, but a different declination. In theſe cases the ebb tide on the equator is the greateſt poſſible ; for the lower poles of the compound ſpheroid are in the equator. Such ſituations occalion a very complicated calculus. We muſt therefore content ourselves with a good approximation.

And firſt, with reſpect to the times of high water. It will be ſufficient to conceive the sun and moon as always in one plane, *viz.* the ecliptic. The orbits of the ſun and moon are never more inclined than 5½ degrees. This will make very little difference ; tor when the luminaries are ſo ſituated that the great circle through them is much inclined to the equator, they are then very near to each other, and the form of the ſpheroid is little different from what it would be if they were really in conjunction or oppoſition. It will therefore be ſufficient to consider the moon in three different ſituations.

I. In the equator. The point of higheſt water is never far-

@@@[m]\* See Mr Cassini, Mem. Acad. Paris, 1734.