

# The influence of the sun, moon and earth tides

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**Abstract.** Tidal phenomena, a ubiquitous spectacle along coastlines, have captivated human curiosity for centuries. It can be involved in some small activities like fishing on the sea. Also, some big activities like the prediction of the position of the Earth should take the consideration of tides. This paper is aimed to have a summary of the formation and the principles of tides. Then, according to the essential theory, some applications are discussed based on the fields of astrology, geography, and clean energy. The principles of these applications are summarized and concluded into some useful information. The information that people derive from tides is a significant amount which can help humans make more efficient methods for the prediction of some phenomena like earthquakes and the movement of moons. As a result, The value of tides is still a potential topic that can help human progress in human beings.

**Keywords:** Tidal force, Earth tides, Periodic tides, Tidal friction

## 1. Introduction

Tides, are a very common phenomenon that every person who has been to the seaside has seen. On our planet, most coast lines have high tide and low tide. Under normal circumstances, the coast will experience two periods of high tide and low tide, which is called the semi-diurnal tidal cycle: it is about 12 hours and 25 minutes per cycle, so the time interval between each high tide and low tide is about 6 hours, 12 minutes and 30 seconds, but this is only a special case that happens around the region equator. Some land with special texture does not apply for this period [1]. Different regions' fishermen depend on the period of high tide and low tide to ensure their ship will not run aground and safer navigation.

In a word, tidal phenomena are important and strange, so the theory is worth being researched. The tidal phenomena result from the tidal force which is caused by the gravitational attraction between the Moon, the Earth, and the Sun, especially by the Moon. As a result, in order to better utilize the benefits of tides, this paper analyzes how tidal phenomena are formed and the application scenarios of tidal phenomena and explores which directions deserve more in-depth research by scientists. This study can help human progress in such fields as astrology, geography, and sustainable development.

## 2. The Related Theories

In this Section, theories about tides as well as the reasons for the occurrence of periodic tides are given.

### 2.1. The tidal force

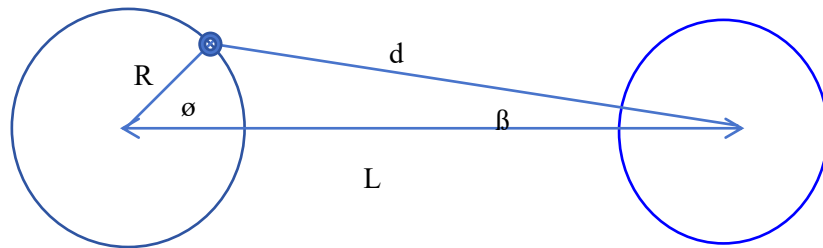
The tidal force is also called the tidal generating force, which results in the stretch of a celestial body along the line towards or away from the center of mass of another body. It is a kind of resultant force mixed with centrifugal force due to inertial force and the gravitational force based on Newton's law.

In the research, the Moon, the Sun, and the Earth can be sketched in a system. And while these three bodies are in different positions, the tidal forces are different. There is a regulation that happens periodically. Based on Figure 1, the formula of the tidal force of a point on the Earth (R is the radius of the Earth) to the content of mass (m) of the celestial body can be obtained, the details are shown below:

$$F_v = G \frac{m}{d^2} \cos(\varphi + \beta) - G \frac{m}{L^2} \cos \varphi \quad (1)$$

$$F_H = G \frac{m}{d^2} \sin(\varphi + \beta) - G \frac{m}{L^2} \sin \varphi \quad (2)$$

G is the universal gravitational constant of  $6.6 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$ , L is the distance between the center of mass of the Earth and the center of mass of the celestial body [2].



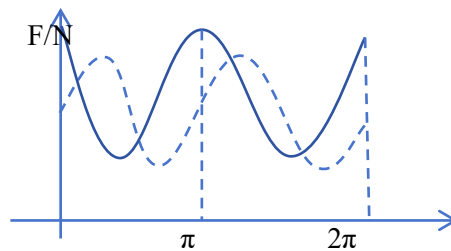
**Figure 1.** The composition of the tidal force

### 2.2. The Main factor of the periodic tides

A special case can be taken to research the main factor of periodic tides. This case is the point located on the line of the line between the mass center of the Earth and that of the Moon. We can only take the horizontal tidal force into account. The formula is  $F_{ax} = 2GmR/L^3$  [3]. Then, Plugging the sun and moon data into the formula yields that the moon's tidal force is 2.2 times that of the sun. As a result, during the calculation of researching the effect of other celestial bodies on the Earth's tide period, only the moon can be taken into account.

### 2.3. The periodic tides

For Equations 1 and 2, replacing the parameters G, m, d and L of the moon and the earth, two trigonometric functions shown in Figure 2 can be derived.



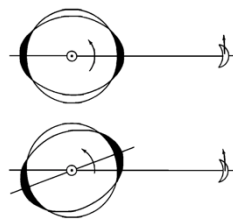
**Figure 2.** The relationship between the position and the tidal force

In Figure 2, the dotted line refers to the horizontal tidal force and the solid line is the vertical tidal force. When in 90 degrees and 270 degrees. The result is approximately zero. When in 0 degrees and 180 degrees, the result is the maximum. As a result, during the day, seawater will experience two high tides at 0 and 18-0 degrees and two low tides at 90 and 270 degrees.

#### 2.4. Tidal friction

Tidal friction has been a problem for scientists for a long while and nowadays still has a high popularity. The tidal force is caused by the rotation of the Earth itself. For the reason of the liquid on the surface of the Earth has the internal resistance to flow, which will cause a friction force which is the so-called tidal friction.

The shape of the surface of the earth elapses due to the affect of the tidal force caused by the sun the moon and the rotation of the earth itself [4]. On top of that, if the factors of rotation have not been taken into account, the top of the tides will situate at the connection between the center of mass of the earth and the center of mass of the moon. Then, considering the factor of rotation, the seawater on the surface of the earth is a fluid, and the common fluid has the property of tangible forces that cause friction. Thus, as shown in Figure 3, the top of the tides will depart the connection of the two bodies' center of mass.



**Figure 3.** The effect of the Earth's rotation on the top of tides [5]

### 3. Applications of tides

#### 3.1. Applications for astrophysics and cosmology

Due to the deflection caused by the tidal friction, this phenomenon will induce a moment on the moon and influence the trace of the moon and also will cause a continuous elongation of the daytime, but relatively in a small amount which people will not be conscious about it. The elongation of daytime is related to the distance of the moon to the earth. Thus, scientists can derive the original date of the moon by the test and research on the relationship between the distance between the earth and the Moon and the daytime changing rate. Moreover, the principle can be also used for other planets and their moons. For a more accurate test of the daytime changing rate in the future, scientists may derive a result of the origin of the moons of any planet.

#### 3.2. Discoveries of the Earth's natural features

The test of solid tidal force can contribute to the research on some regions' geographic structure. The solid tidal force can influence the shape of the earth, and scientists can get data on tide factors on the ground by measuring with certain devices. Then, through the analysis of the data gotten, scientists can derive the composition of the crust. In 1995, Chinese scientists Tang and Chang and their group measured the tide factor in Lanzhou. They measured the factors of water level solid tide, long period wave, diurnal wave, half-diurnal wave, and 1/3 diurnal wave of inclined earth tide, by the use of Venedikov harmonic analysis [6]. Finally, they got the analysis of the horizontal composition of the crust. Most of that, scientists also found that the reason for the abnormal phenomena in "Three Belt" corresponds to the resonance of the tidal force. Especially for some extraordinary rainstorms which have already met the requirement of most conditions [7]. These two theories can contribute to the analysis and prediction of some natural hazards and help people understand the underground geographic features.

Studying the interactions between tidal forces and other environmental elements can help to understand Earth's dynamic processes at a more complex level. In summary, the thorough investigation of solid tidal forces in Lanzhou highlights the significance of ongoing research in this

area for a thorough understanding of Earth's dynamic systems. It also advances our knowledge of geological structures and serves as a useful tool for hazard prediction.

### *3.3. The prediction of the earthquake*

In the past, people found that seismic phenomena with a high earthquake magnitude usually happen in a period that is related to the tidal period. Later, Scientists discovered that the essence of the cause of the earthquake is a kind of movement of the Earth plate, and the tidal force itself is a kind of force that not only deduced on the seawater on the surface but also acts at crust and other geologic structure. This kind of tidal force is called the solid tidal force. It can influence the shape of the solid part of the planet by exerting the force on the plate in a small amount. This makes somebody believe that there must be a relationship between the tidal period and the earthquake. And the argument about whether tides can trigger an earthquake has lasted for a long time. Darwin found that More than five-magnitude shallow oblique-slip and dip-slip earthquakes seem to be associated with tidally-generated shear strains that are prone to failure, but at the same time, Darwin denied the link between tides phenomena and strike-slip earthquakes or any earthquakes that are more than thirty kilometers depth [8]. What's more, in 2007, Chinese scientist Zhang and his group found that there was a disorder of electric tidal waves before the occurrence of some earthquakes with high magnitude. This is influenced by likely the tidal waves' electric field resonance effect which is affected by the tidal force [9]. In the future, scientists can research further on the tidal force's influence on the exact different layers, and integrate these factors together to measure the influence on the earthquake. This can make the prediction more accurate. As a result, Although the tidal force is not the critical factor of the occurrence of the earthquake, it still plays a pivotal role while the magnitude of the earthquake is low [10].

### *3.4. Utilization of tidal energy*

The tidal energy is a clean energy that can be used. Since the tide movement contains the kinetic energy through the process of high tides and low tides. This kind of energy is one of the few sources of energy that does not come from sunlight but incurs the gravitational force from a lot of celestial bodies. People can utilize the kinetic energy and transfer it into electric energy. Its theory is similar to water power. The power stations accumulate seawater during the high tide period and release the seawater during the low tides, through the process of releasing, the kinetic energy of seawater can be transferred into the form of electric energy [11]. However, the external cost of the power station which utilizes the kinetic energy of tides is high. The power stations are always built near the coastline. This is a kind of land reclamation. The surrounding fishes' living style will be disturbed, thus increasing the capture of the local ecosystem. To solve such a puzzle, the future developing direction can be the undersea power. Building the power station under the sea instead of directly building by the coastline can spare a lot of space on the surface of the ground and capture the ecosystem in less extent.

## **4. Conclusion**

This paper analyzes potential applications of the tide phenomena in the future by the use of some basic theories of tides such as tidal force and tidal friction. The analysis derives some useful aspects from the tides. Firstly, Scientists can measure and calculate the possible position of certain celestial bodies by the data of the body's tidal friction. Then, Scientists can make the prediction of some high-level earthquakes by measuring the period of tides and can also detect the underground conditions by the test of some data of tidal factors above the ground. Moreover, a sustainable resource can be obtained from the utilization of the movement of high tides and low tides. However, the influence of tides on the earthquake and the position of celestial bodies is not the decisive factor. Also, the measurement of the data required is not easy. It will be disturbed by a range of environmental factors such as other planets in the solar system, their influence is small but still can not be completely ignored. For future research, scientists can put more effort into the development of some devices that can bring a precise measurement. Thus, further study may focus on the accurate calculation and the measurement of data

that can be tested on the ground to get a conclusion with more details about the relationship between phenomena like earthquakes and celestial bodies' movement.

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