



www.astrosociety.org/uitc

No. 45 - Winter 1999

© 1999, Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, CA 94112.

This Restless Globe

A Look at the Motions of the Earth in Space and How They Are Changing

by Donald V. Etz

- [The Major Motions of the Earth](#)
- [How These Motions Are Changing](#)
- [The Orientation of the Earth in Space](#)
- [The Earth's Orbit](#)
- [Precession in Human History](#)
- [The Motions of the Earth and the Climate](#)
- [Conclusion](#)



Our restless globe and its companion. While heading out for its rendezvous with Jupiter, a camera on NASA's Galileo spacecraft snapped this 1992 image of Earth and its Moon. The terminator, or line between night and day, is clearly visible on the two worlds. Image courtesy of NASA.

The Greek philosopher Heraclitus of Ephesus, said 2500 years ago that the perceptible world is always changing.

Heraclitus was not mainstream, of course. Among his contemporaries were philosophers like Zeno of Elea, who used his famous paradoxes to argue that change and motion are logically impossible. And Aristotle, much admired in ancient Greece and Rome, and the ultimate authority in medieval Europe, declared "...the earth does not move..."

We today know that Heraclitus was right, Aristotle was wrong, and Zeno...was a philosopher. Everything in the heavens moves, from the Earth on which we ride to the stars in the most distant galaxies. As James B. Kaler has pointed out in *The Ever-Changing Sky*: "The astronomer quickly learns that nothing is truly stationary. There are no fixed reference frames..."

The Earth's motions in space establish our basic units of time measurement and the yearly cycle of the seasons. Over the centuries of human civilization, these motions and their changes have prompted some of the earliest and most enduring scientific endeavors. Over the few thousands of millions of years of Earth history, they appear to have markedly affected its climate.

To bring it all together, and to dispel some misconceptions, we will take a look at the major motions of the Earth and the more important ways they are changing.

The Major Motions of the Earth

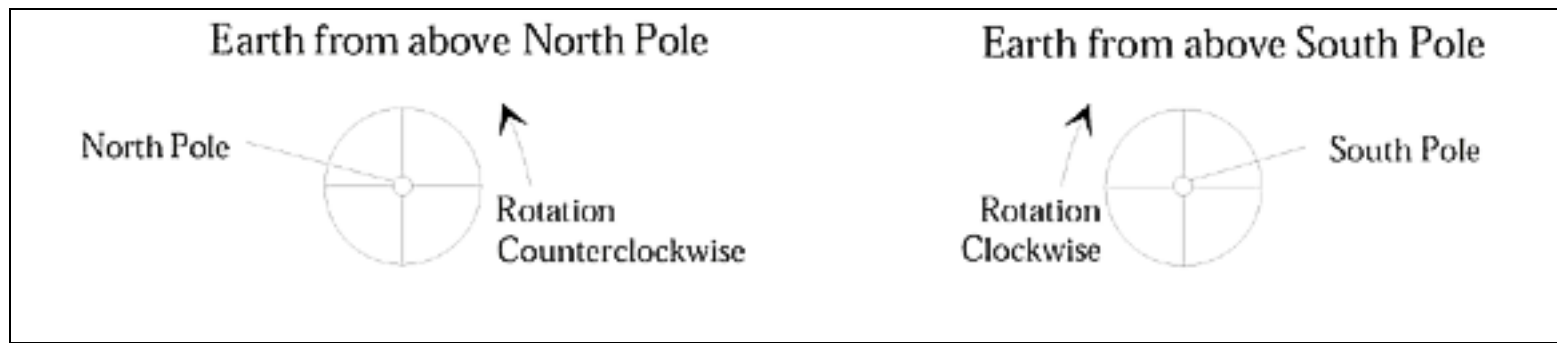


Figure 1. Earth's rotation as viewed from above the north and south geographic poles. Illustration courtesy of author.

The Earth rotates eastward on its axis-counterclockwise, viewed from above the North Pole; clockwise, viewed from above the South Pole-to give us our days (see [Figure 1](#)). The plane of the Earth's rotation (the equator), extended to the background of stars, is called the celestial equator. The axis of its rotation can be extended to mark the celestial poles in the background of stars, north to a point about 1° from Alpha Ursa Minoris (Polaris), and south to a point about 1° from Sigma Octantis (a fairly dim star sometimes called Polaris Australe).

The Earth revolves around the Sun-also counterclockwise viewed from above the North Pole, clockwise viewed from the South Pole-to give us our years (see [Figure 2](#)). The plane of the Earth's orbit is called the ecliptic (where eclipses happen). This plane passes through the 12 so-called zodiacal, or animal-form constellations, plus often-overlooked Ophiuchus. The ecliptic's axis currently extends north to the north ecliptic pole, a point in Draco, and south to a point in Dorado we call the south ecliptic pole.

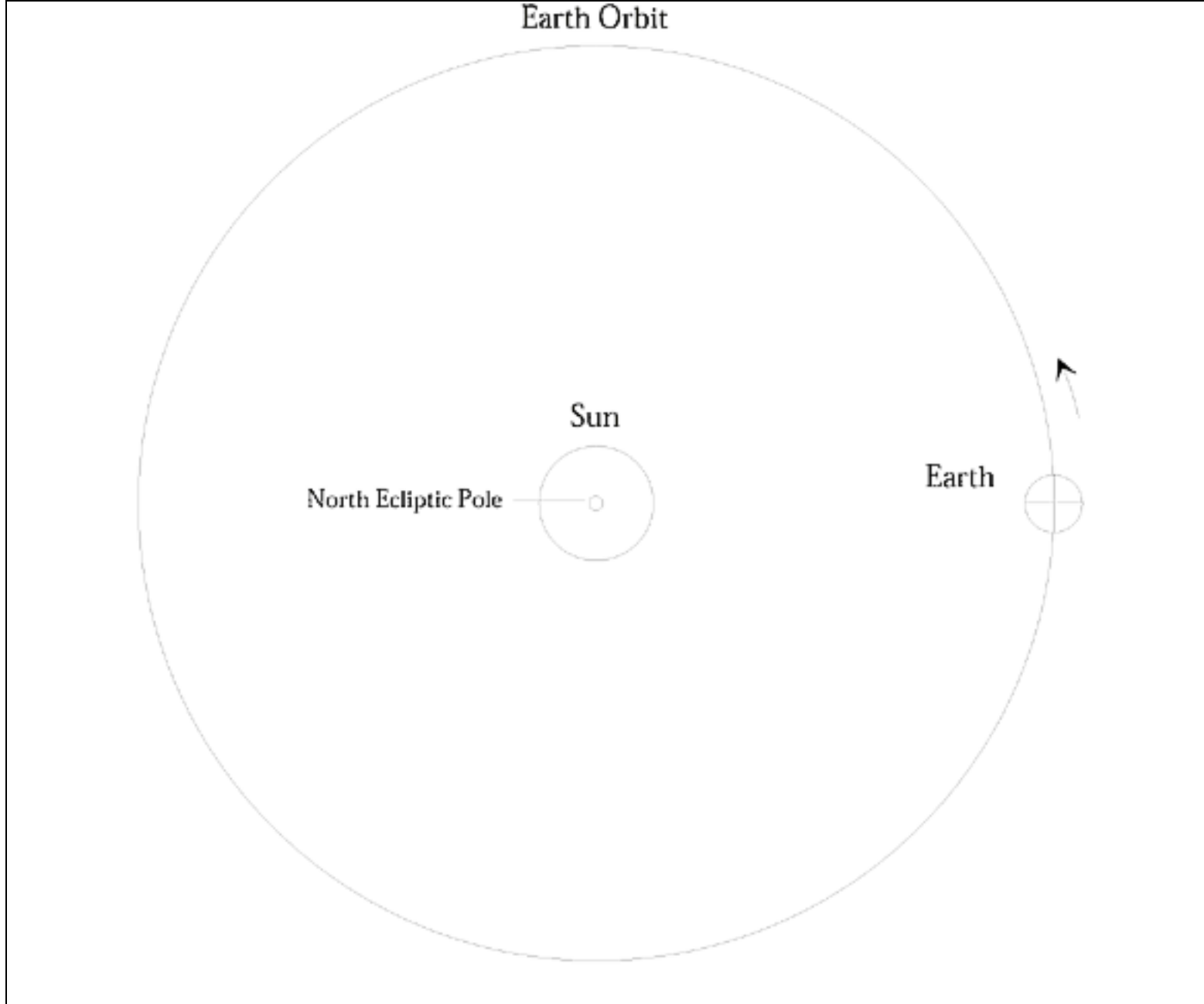


Figure 2. Earth's orbit as viewed from the north ecliptic pole. Illustration courtesy of author.

The Earth's direction of revolution probably arose from the rotation of the early nebula from which the Solar System formed, and its direction of rotation perhaps from the impacts of other large (proto)planetary bodies as the Earth grew.

Obliquity: Seasons

The celestial equator is currently tilted about 23.44° in relation to the ecliptic ([Figure 3](#)). This angle is called the obliquity of the ecliptic. The reason for this particular obliquity is not clear. A value close to it was probably established very early in the history of the Solar System. However, some writers suggest that it was originally much greater.

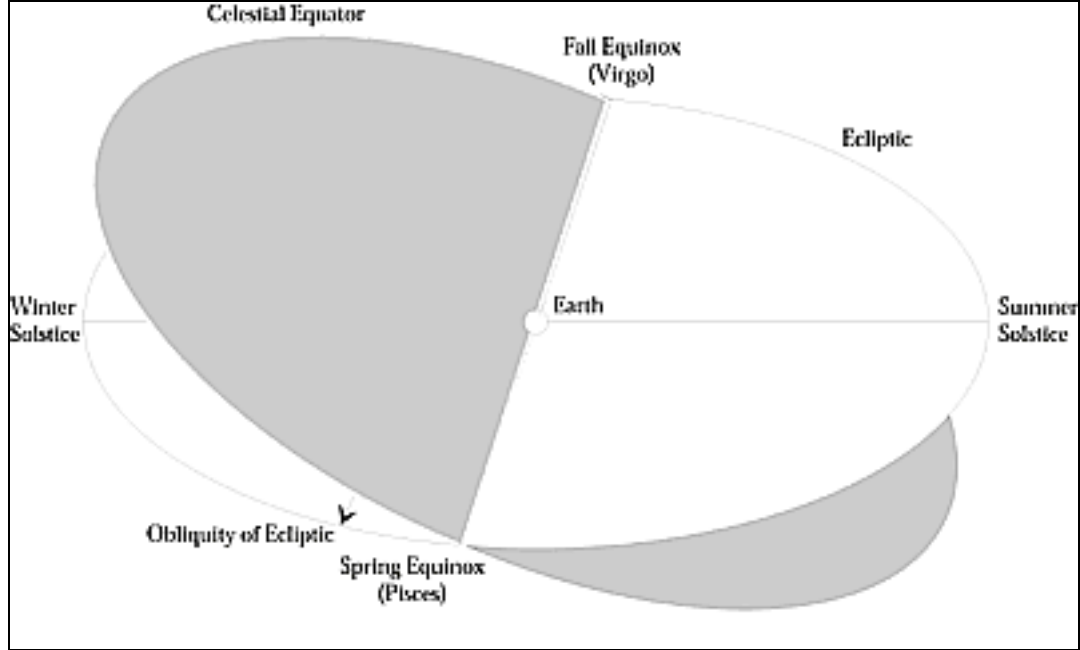


Figure 3. The celestial equator and the ecliptic. Illustration courtesy of author.

The celestial equatorial plane and the ecliptic currently intersect in Pisces, not far from the border with Aquarius, and in Virgo, not far from the border with Leo. The Sun in its apparent yearly progress along the ecliptic reaches the Pisces intersection at the Spring equinox on 21 March and the Virgo intersection at the Autumn equinox on 23 September. This annual variation gives us our seasons, opposite in the northern and southern hemispheres. The Sun shines more directly on the northern latitudes in the Spring and Summer, when it is north of the celestial equator, and on the southern latitudes in the Fall and Winter, when it is south of the celestial equator.

Eccentricity

The Earth's orbit around the Sun is not a perfect circle, but slightly "stretched" into an ellipse ([Figure 4](#)). Its eccentricity is currently about 0.0167, which means that the Earth-Sun distance varies about 1.67% of the mean distance. The Sun is not at the center of the ellipse, but at one of its two geometric focal points, each currently about 2.5 million km from the center. Hence, the Earth-Sun distance varies some 5 million km throughout the year. The Earth is closest to the Sun -- at perihelion -- about 2 January, when the Sun is in the middle of Sagittarius, and farthest from the Sun -- at aphelion -- about 4 July, when the Sun is in the middle of Gemini.

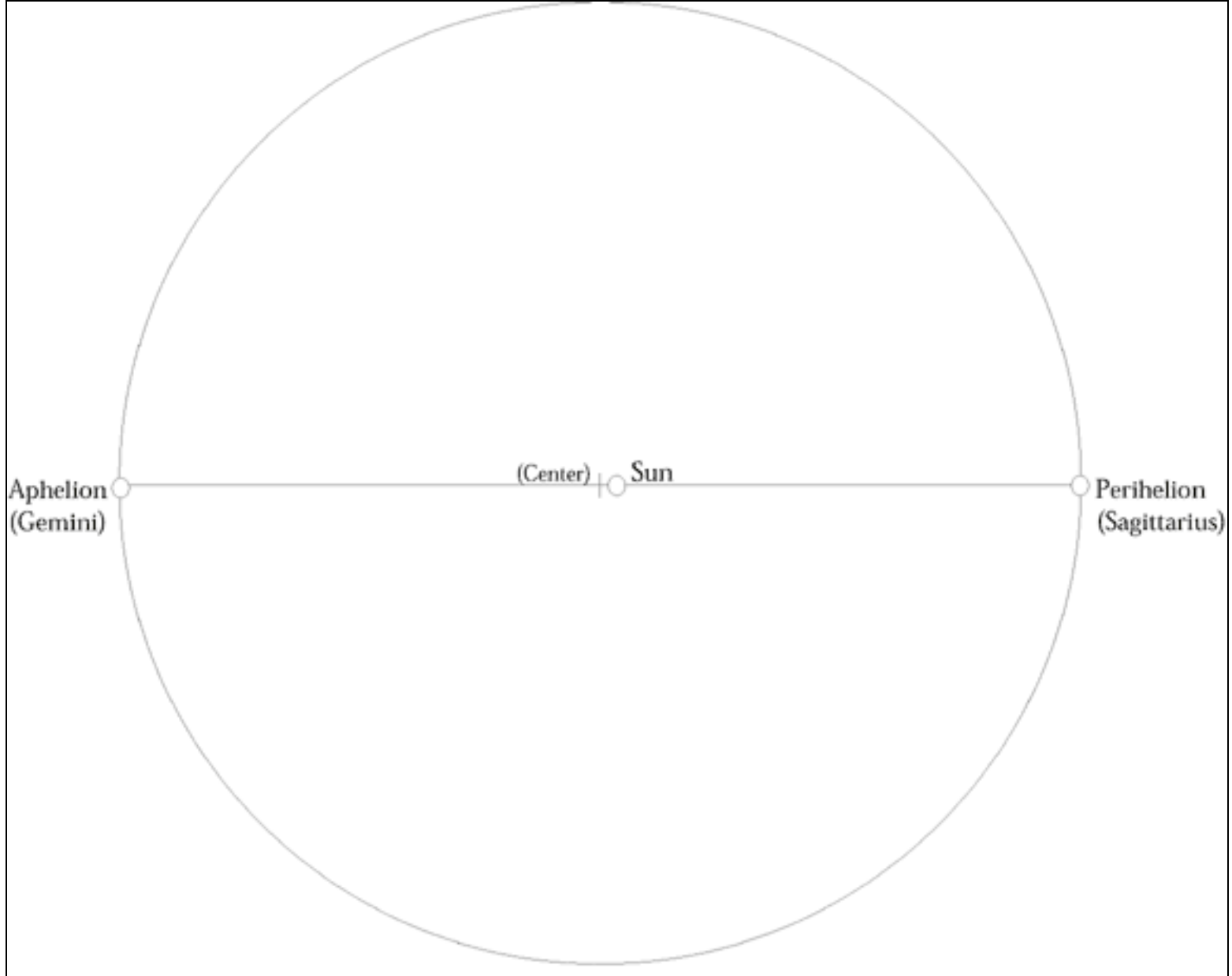


Figure 4. The small eccentricity of the Earth's orbit. Illustration courtesy of author.

Because the difference in distances is small, this eccentricity does not have a significant effect on the Earth's climate. However, it does affect the duration of the seasons, since the Earth takes longer to cover the more distant segments of its orbit. Currently, summer is for us in the North our longest season (93.65 days) and winter our shortest (88.99 days).

[1](#) | [2](#) | [3](#) | [4](#) | [next page >>](#)

[back to Teachers' Newsletter Main Page](#)