Olbers's Paradox Encyclopedia Article

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Olbers's Paradox

Why is the night sky dark? This apparently simple question, known as Olbers's paradox, actually reveals something deep and fundamental about the **universe**. Although named after the German physician and amateur astronomer Heinrich Olbers (1758-1840), who discussed the problem in 1823, **Johannes Kepler** was the first to consider it in 1610.

Olbers's paradox begins by saying that the apparent brightness of a star on the sky decreases with the square of the distance to the star. But, since the area the star appears to cover also decreases with the square of the distance, this means that the apparent brightness per unit area on the sky does not depend on the distance to the star. If one assumes that the universe is homogeneous, infinitely old and infinitely large, this means that every line of sight should intersect at one of the infinite number of **stars**, and the night sky should be infinitely bright! Hence the paradox.

It is best to note that in order to work, like most paradoxes, Olbers's paradox must make some assumptions, most of which are explicitly stated, while at least one is implicit. These are: (1) the universe is infinitely large; (2) the universe is infinitely old; and (3) the universe is homogeneous.

Since the average **density** of luminous **matter** in the universe is non-zero, assumption (3) combined with (1) leads to the conclusion that the universe has an infinite amount of luminous matter in it. Since it takes **light** a finite time to travel to us from any point in **space**, assumption (2) is necessary in order to see distant stars.

In order to solve the paradox, one or more of these assumptions must be invalidated. Some people might think that dust can blanket the earth, effectively obscuring the **radiation** from the infinite amount of luminous matter in an infinitely old, infinitely large, homogeneous universe. (Indeed, this was Olbers's suggested solution to the paradox.) Assumption (2) must not be true, however, since in an infinitely old universe, even the dust would **heat** up until it reaches **equilibrium** with the radiation by emitting its own thermal emission at the same rate at which it absorbs radiation, and the paradox still applies.

Modern **cosmology** has shown from a variety of observations that the universe is expanding, and therefore has a finite age. Hence, most astronomers today would agree that the resolution to Olbers's paradox is that the universe is not infinitely old.