Cosmologists are often wrong, but never in doubt.

Lev Landau

Application: Did the Universe have a Beginning?

In *The Size of the Universe*, we discussed Edwin Hubble's 1929 discovery that the universe was expanding. We stated his observations in the form of a differential equation:

$$d' = H_0 d,$$

where d is the distance of an object from the Earth and H_0 is Hubble's constant. From this equation, can we determine whether or not the universe had a beginning? What we mean by "beginning" is a time when d and d' are zero.

The answer is that using the equation $d' = H_0 d$, we *can* determine whether the universe had a beginning. But unfortunately, our conclusion is probably wrong!

The reason the conclusion is probably wrong is that it turns out (and we'll explain this later) that Hubble's constant isn't actually constant. Instead, it's closer to the truth to write

$$d' = Hd,$$

where H is a quantity that varies with time.

Laboratory: Did the Universe have a Beginning?

Even though

$$d' = H_0 d$$

is probably false, we ask you to use it to analyze the history of the universe. Assume that H_0 is constant and that at the present time d is some non-zero quantity. Determine whether or not d was ever zero.