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HEADLINE: The end: Clearer, but not nearer;
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BYLINE: By Chet Raymo

BODY:
Scientists are pretty sure how the **universe** began. They are less certain how it will end.

The beginning was explosive. The **universe** had its origin about 15 billion years ago in an **expanding** fireball of radiant energy. Space and time unfurled from a tiny seed of infinite energy, like a balloon inflating from nothing, cooling as it swelled. Energy became matter; matter became stars and galaxies, racing outwards.

Today the galaxies continue to fly apart, impelled by their initial impetus, bearing the Milky Way and other galaxies to ever greater separations.

The evidence for an explosive beginning is various and compelling. First, the present outrush of the galaxies suggests that they were closer in the past, and on top of each other about 15 billion years ago.

Calculations based on a Big Bang beginning neatly account for the present abundances of elements in the universe: how much hydrogen, helium, and so forth, relative to each other.

The faraway quasars give a glimpse of the violent formation of the galaxies. And in every direction, uniformly, our telescopes see the afterglow of the Big Bang, the blinding light of the beginning stretched almost imperceptibly thin, in precise agreement with calculations.

Less clear is where the universe will go from here.

There are two possibilities: Either the universe will expand forever, carrying the galaxies always farther apart, into cold and darkness, infinitely dispersed; or it will cease expanding and begin to contract, the galaxies drawing closer and closer, ending as it began in a blaze of radiant energy.

A whimper or a bang? A terminal glide into Stygian gloom, or annihilation in blinding light?

Which it will be depends upon the present velocity of the galaxies relative to each other, and how much gravity is working to slow down the expansion.

The situation is rather like shooting a projectile up in the air: Will it climb forever, escaping the gravitational pull of the Earth? Or will it slow to an instantaneous stop, then fall back to Earth, gathering speed?

It all depends on whether the initial velocity of the projectile imparts sufficient energy to overcome gravity, the so-called "escape velocity." At the Earth's surface, the escape velocity is 25,000 miles per hour, which it why it takes a pretty big rocket to launch a space ship to the moon or planets.

Like a rocket engine, the Big Bang hurled the galaxies outwards; gravity is pulling them back together. Do the galaxies have sufficient speed to overcome their mutual gravity? Do they possess the escape velocity? The question turns out to be surprisingly difficult to answer.

Two things are important to know: What are present and past expansion rates of the galaxies? And how much matter is acting to slow down the expansion?

During the past year astronomers have made tantalizing progress towards finding answers.

Several groups of researchers have been watching supernovas in distant galaxies. These extremely bright exploding stars can be observed billions of light-years away and used as indicators of the universe's changing expansion rate.

The recessional velocities of the supernovas can be deduced from a stretching of the wavelengths of their light, just as the pitch of an automobile's sound is lowered as it races away from us. The data indicate that the expansion is not slowing down enough to make the galaxies fall back upon themselves.

The Hubble Space Telescope has made these observations more precise than ever before.

Other groups have been comparing the actual distribution of galaxies to computer models for how the universe should evolve with different densities of matter. The best fit between observation and calculation assumes there is not enough matter to stop the expansion.

Apparently, the universe will expand forever.

Five billion years from now the sun will swell into a red giant, then collapse to a glowing ember that will slowly fade from sight. A cold, frozen, lifeless Earth will circle an extinguished star.

A hundred billion years will pass and the universe will be stretched exceedingly thin. The last dregs of energy will be squeezed out of star-birthing nebulas. No new stars will be born. The sky will grow increasingly dark.

Somewhere, in a last pool of cosmic warmth, perhaps in a faraway galaxy, a final microbe will expire. Life, which for billions of years had burned among the stars like a cool blue flame, will flicker out. A dead universe will slide into black oblivion.

Each of us will react to this now likely scenario in our own way. For myself, I find something grandly sedate and dignified about such a finish, something that suits my mature mood. No recurring fireballs for me, please. I'm ready for that long, dark cosmic nap.

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