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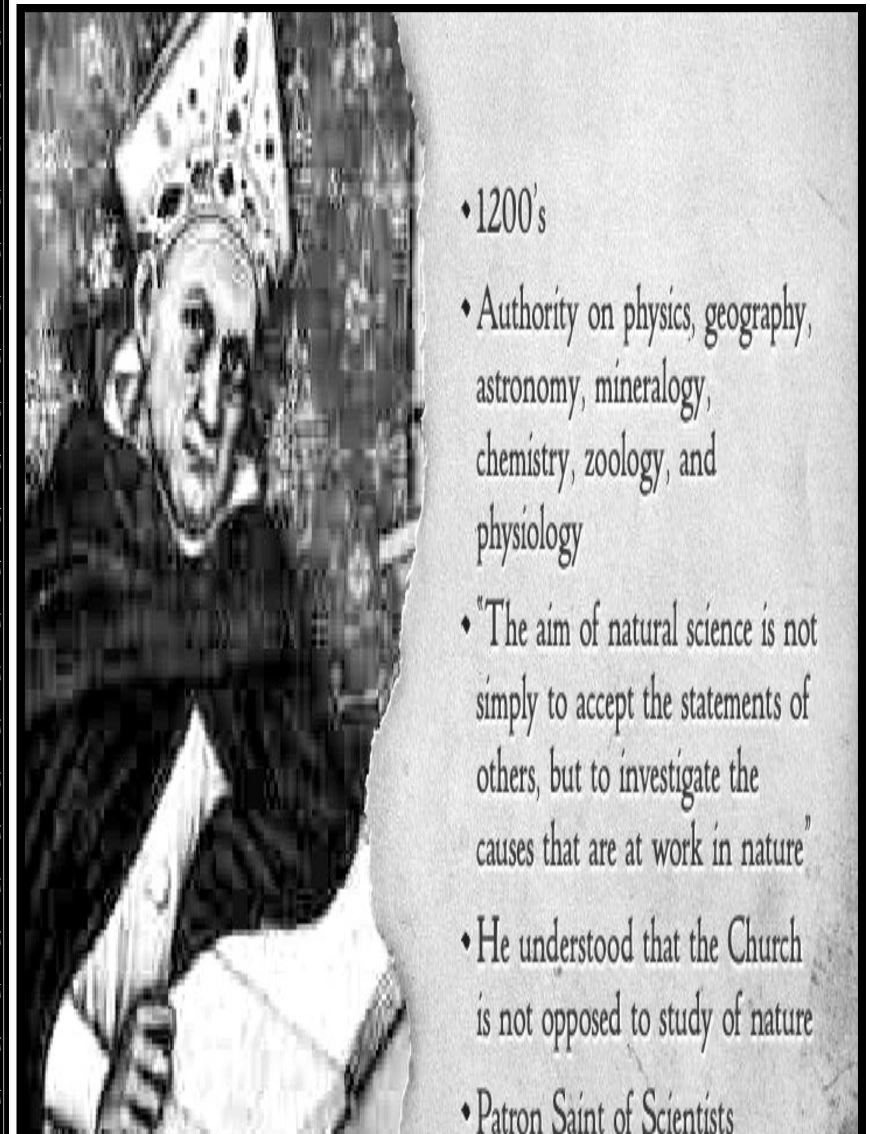
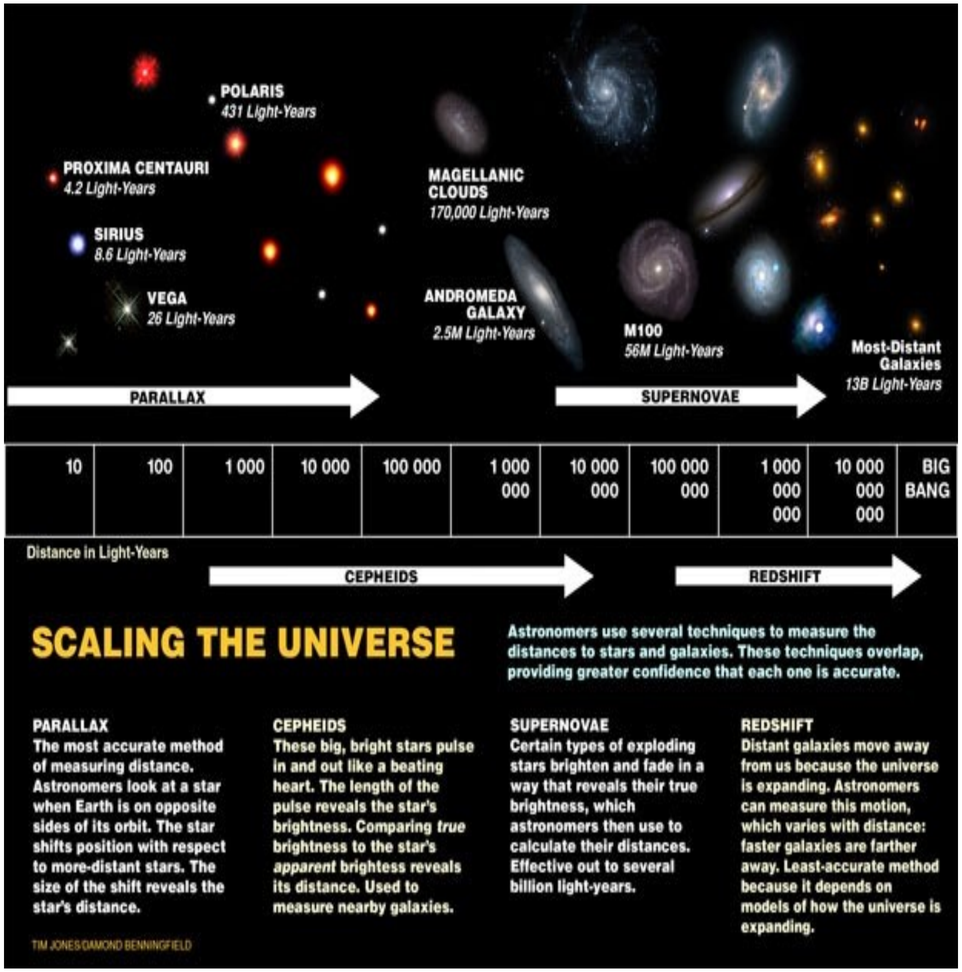
Catholic Physics - Reflections of a Catholic Scientist - Part 31

Philosophical Issues in Cosmology 5: What Measurements Tell Us



Philosophical Issues in Cosmology 5: What Measurements Tell Us

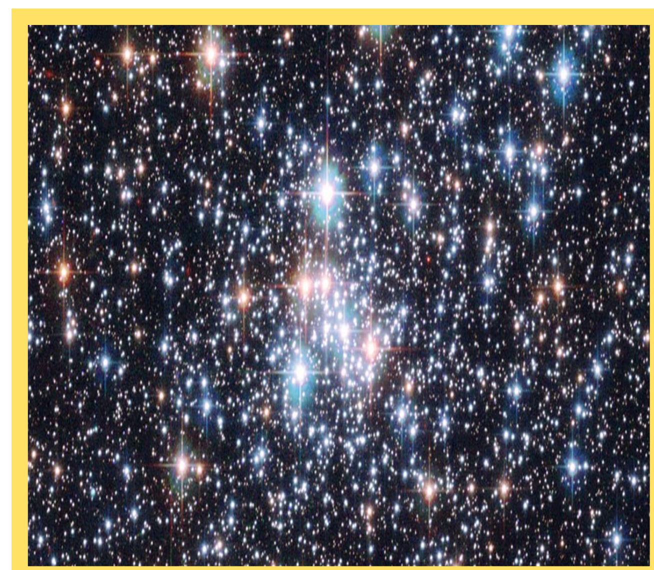


Astronomical Distances. From telescopes.stargate.org

"When you can measure what you are speaking about, and express it in numbers, you know something about it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the stage of science." Lord Kelvin.

Misconception 2: The universe expands from a specific point, which is the centre of the expansion. All spatial points are equivalent in these universes, and the universe expands equally about all of them. Every observer sees exactly the same thing in an exact RW geometry. There is no centre to a FL universe.

Misconception 3: Matter cannot recede from us faster than light. It can, at an instant; two distantly separated fundamental observers in a surface {t = const} can have a relative velocity greater than c if their spatial separation is large enough. No violation of special relativity is implied, as this is not a local velocity difference, and no information is transferred between distant galaxies moving apart at these speeds. For example, there is presently a sphere around us of matter receding from us at the speed of light; matter beyond this sphere is moving away from us at a speed greater than the speed of light. The matter that emitted the CBR was moving away from us at a speed of about 61c when it did so.



Dark Energy

Observations of red shifts from distant supernovae and from temperature anisotropies in the cosmic background radiation suggest that there is a “dark energy”, a pressure (as in the “lambda” constant in Einstein's original formulation) that makes the expansion of the universe accelerate. (What this is saying is the expansion rate is slower for older, more distant objects, faster for more recent, closer objects, so there is an acceleration of the rate.)

Evidence for an Expanding Universe

The following observations, in addition to the red shift, confirm the picture of a universe expanding from a hot big bang: the cosmic background radiation, the relative abundance of hydrogen to helium in the universe (about 3/1) and the lack of heavy elements in far distant galaxies. The cosmic background radiation is like the embers of a burnt-out fire, the embers of the hot “Big Bang” spread evenly throughout the universe. The small irregularities in the cosmic background radiation indicate the fluctuations that grew into stars and then galaxies. The relative abundance of hydrogen to helium is consistent with models of element formation that took place at an early, high temperature stage of the universe. For far distant galaxies (10 billion years light distance, say), they are also at an early stage of development (remember, going in distance is also going back in time) and therefore heavy elements have not yet formed by the collapse of red giant stars.

Ellis lists (among others) the following common misconceptions about the expanding universe:

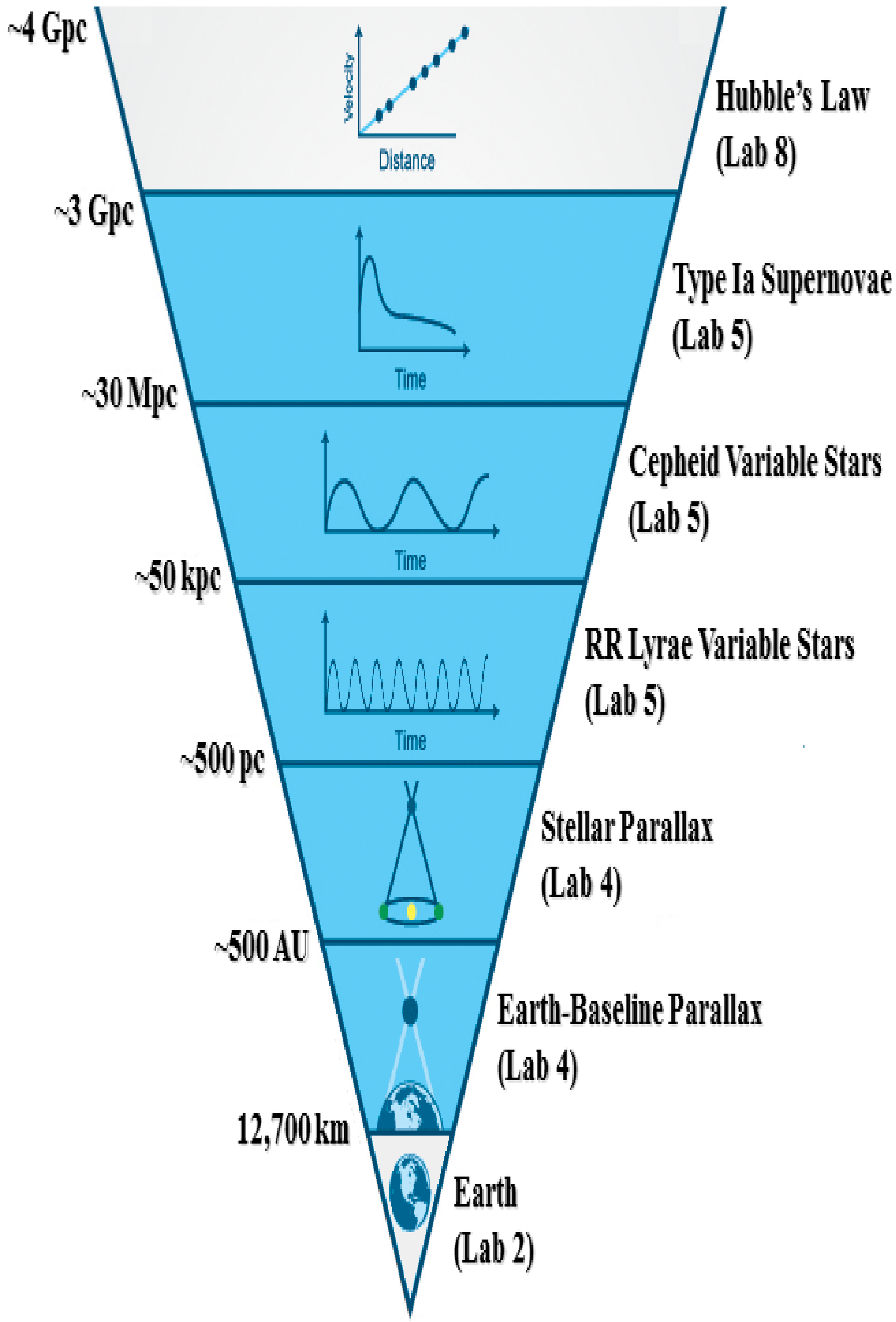
Misconception 1: The universe is expanding into something. It is not, as it is all there is. It is just getting bigger, while always remaining all that is.

This, the fourth in a series summarizing George F.R. Ellis's article on Philosophical Issues in Cosmology, will deal will information provided by measurements. In addition to Ellis's article, Ned Wright's Cosmology Tutorial web site gives a clear, accurate and detailed picture of how astronomical measurements give cosmological data:

The following types of data are primary: positions and luminosities of stars and galaxies (including x-ray, UV, visible, IR, microwave and radio-frequency radiation); wavelengths of spectral lines from these objects; Doppler shifts of such wavelengths (shifts in the wavelength that depend on the velocity of the object emitting the radiation); frequencies, intensities and polarizations of the microwave cosmic background radiation (CBR).

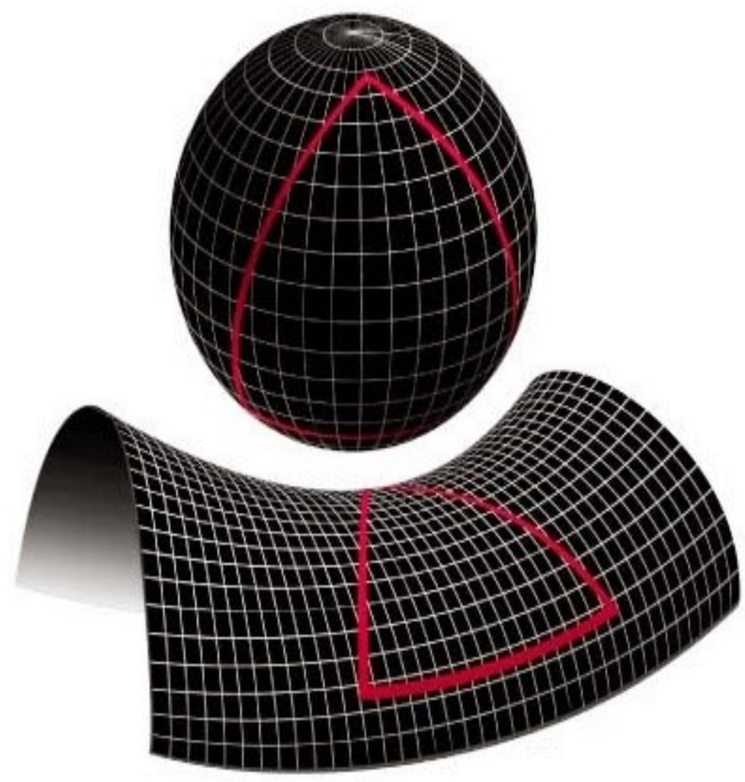
It's important to realize that there is, so to speak, a “ladder” of inferences of secondary data from these primary data. For example, the distances of nearby stars (10-100 light years or so distant from us) can be estimated relatively accurately by parallax measurements. From the intensity of light observed, one can then estimate accurately the intrinsic brightness of these stars. One can then use other properties, at known distances, to set up what are called “standard candles”: properties that relate to the intrinsic brightness, so that the intrinsic brightness can be inferred, to give from the observed intensity an inferred distance.

Various standard candles are used at various distances, including cepheid variables to supernovae and galactic lensing of quasars. One of the first standard candles was the intrinsic brightness of the Cepheid variables. Hubble used these to estimate the distance of stellar objects and to construct his plot of red shift versus distance, which was the basis for the expanding universe theory. Since that time more accurate measures have given very good linear relation between red-shift (velocity moving away from us) and distance from us.



Distance Ladder from Skynet University(UNC)

One can also count the number of objects within the field of view and from this make an estimate of the total number of objects to be seen, and thus infer the total (baryonic—ordinary) mass. From this astronomical data one can infer the following: the actual ratio of matter to a critical value; this ratio is designated "omega 0" (with uppercase Greek letter). If omega 0 is >1, space-time is positively curved (like a sphere) and the universe expansion will eventually turn into a collapse, for a "big crunch"; if omega 0 is = 1 space-time is flat and the universe will expand in a uniform way; for omega 0 <1, the universe is curved as in a saddle surface, and will expand indefinitely.



Space Curvature: top, omega 0 >1; bottom, omega 0 <1
from Hendrix at University of Oregon