dense, prestellar stuff, perhaps a bit like Gamow's Ylem, but not confined to the early universe, and then in turn expel gaseous nebulae from their surfaces to produce configurations like the stars and gas of Orion. (Conventional stellar evolution tracks do roughly the reverse, beginning with gas and ending with very dense remnants.)

As time goes on, the various possible interactions between astronomy, cosmology, particle physics, and so forth that are discussed in the following sections will move to this one. I am not prepared to guess which will then be seen as "interesting historical examples" and which as "that was an astronomer who thought he was Feynman."*

Leo Goldberg

Academician Viktor Ambartsumian, who died last year, was among the first astronomers to propose a specific mechanism for the formation of expanding clusters of massive, young stars. He later extended the idea (expansion from some kind of very dense, prestellar material, different from known interstellar or laboratory gases) into a possible explanation for quasars. (Courtesy AIP Emilio Segrè Visual Archives)

THINGS THAT DO NOT GO BUMP IN THE NIGHT

You could write a whole book about the exotic particles, properties, and processes that we know do not exist because they would violate some set of astronomical observations. In fact someone has (Georg Raffelt; see the list of "more reading" on page 51). The general idea is that stars must be allowed to form from the interstellar medium, do their nuclear thing for millions or billions of years, and die as planetary nebulae + white dwarfs (from low mass stars) or as supernovae + neutron stars or black holes (from stars of more than about 8 solar masses), at all times adhering to a set of nonlinear differential equations that describe conservation laws, rates of energy generation and transport, and equilibrium between pressure and gravity. The detection of neutrinos from SN 1987A with very much the temperature, time scale, and flux that had been expected from neutron star formation brought this whole field into considerable prominence. The constraints are sometimes quite tight simply because, on the whole, stars manage pretty well with just the standard-model physics that we are all so tired of.

In addition, any new entities you might want to postulate must not be so numerous and massive as to make the average density of the universe big enough to slow the expansion measurably today (since we see no such slowing). Nor are they (or you) allowed to spoil the set of nuclear reactions at high density and temperature that produce deuterium, helium (3 and 4), and a bit of lithium-7 in the early universe ("big bang nucleosynthesis"). I mention here only a small, representative set of examples and urge you to peruse Raffelt's book for many more and for the corroborative details.

1. There must not be too many magnetic monopoles floating around, or they will short out the large-scale magnetic fields of Jupiter, pulsars, and the interstellar gas. This Parker (for Eugene of Chicago) limit means that such monopoles must have rest masses of at least 10^{16} GeV if they are to be dynamically important in the universe.

2. The magnetic dipole moment of the electron neutrino cannot be more than about 3×10^{-12} of the Bohr magneton, or the neutrinos from SN 1987A would never have

**The original image here was a* New Yorker *cartoon bearing the caption: "That's God. He thinks he's a doctor."*