reprints, I suggest that the authors include a mimeographed list of all their previous publications in the field, with asterisks by papers of particular note. Nothing is more frustrating than to be criticized through ignorance of one's own previous work. Such a list would increase the probability of the recipient finding and reading the author's early papers and important papers and of referring to them in his next publication.

In order to achieve immediate benefit from these professional courtesies, I further suggest that investigators review their publications in the last five years and notify authors cited, and finally that publishers include in their instructions a reminder to authors to notify authors cited.

If these professional courtesies become accepted, I believe that the interchange of ideas and information among scientists would be greatly facilitated, duplication of effort reduced, and disputed points between different schools of thought resolved more quickly.

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Observations on Observational and Other Astronomy

K. S. Thorne's article "gravitational collapse and the death of a star" [*Science* **150**, 1671 (1965)] forms a good illustration of whither science is going and indicates a change which, to us old-timers, is not an improvement. The author starts off by saying, "What is the fate of a star. . . ? This is a question which observational astronomy has done but little to answer . . ." and he then continues, "Despite the paucity of observational data, theoreticians are now able. . . ." Since Thorne admits that, theoretically, there are no equilibrium configurations for dead stars containing more than 1.2 times as many baryons as the sun, that such objects must collapse into a singularity, and that the prospect for observing these is nil, it is hardly fair to blame the observers for not having observed them, and I shall confine my remarks to the dead start of smaller mass.

Having spent more than 40 years trying to find faint stars with large motions, largely for the dual purpose of determining the luminosity function and of finding more white dwarfs—the dying stars of which Thorne speaks—I can only marvel at the author's disregard of what observational astronomy has accomplished. I have found and published data on more than 1300 white dwarfs; Greenstein, using the 200-inch telescope, has done a great deal of very important work on the spectra of the brighter specimens. But don't the theoreticians realize (i) that probably at least half the white dwarfs now known are too faint for spectroscopic observations, even with the 200-inch telescope, and (ii) that to obtain spectra for the other half would probably tie up the 200-inch telescope for the equivalent of several full years, as well as a similar 200-inch in the Southern Hemisphere—which we haven't got yet? Most astronomers think there are a few other problems in observational astronomy that deserve the attention of the 200-inch.

Thorne says that "Astronomical measurements of the masses and radii of radiating white dwarfs are in fairly good agreement with the predictions. . . ." The proper way to state this would be to say that present theoretical predictions are in fairly good agreement with the observed masses—the mass of Sirius B having been known for more than 50 years. No radii have ever been observed; they are calculated from the assumed laws of radiation.

Finally, in a discussion of the central densities of white dwarfs, neutron stars, and so on, the curves drawn are continued to 10^{22} g/cm^3, and in the text the discussion of the theoretical singularities resulting from supernova explosions of massive stars is continued to densities of 10^{49}, beyond which the admission is made that theory is "far from completion." Since we are now talking about nuclear densities of the order of 10^{14} to 10^{15}, these new values represent extrapolations by factors of at least 10^7 to 10^{34}. This brings to mind William Whewell's comment: "The cultivation of ideas is to be conducted as having for its object the connexion of facts; never to be pursued as a mere exercise of the subtlety of the mind, striving to build up a world of its own, and neglecting that which exists about us. For, although man may in this way please himself, and admire the creations of his own brain, he can never, by this course, hit upon the real scheme of nature." This was used as a full-page advertisement in *Science* (10 April 1959, p. 931) by the Rand Corporation, and it might well serve as a text for the theoretician in the computer lab.

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Luyten's contributions to our understanding of white dwarf stars are so basic to all work in the field that his comments deserve serious attention.

Luyten's inference that I am dissatisfied with the contributions of observational astronomy to our knowledge of the deaths of stars is a misunderstanding resulting from my poor choice of phraseology. In actuality, I find it inspiring that, despite the great technical difficulties involved, observers can discover as much as they have about the final stages of stellar evolution.

Of the four subtopics in "Gravitational collapse and the death of a star" —white dwarf stars, dynamics of supernovae, neutron stars, and collapse to zero volume—only white dwarfs are amenable to extensive observational study. Luyten wishes that I had devoted a larger portion of my article to observational results on white dwarfs. However, great progress has been made recently in our theoretical understanding of supernovae, of neutron stars, and of gravitational collapse, whereas by comparison white-dwarf observations and theory have changed little in the last 5 years. To do justice to exciting recent developments, it was necessary to be brief in describing the beautiful but well-known observational and theoretical results on white dwarfs.

Luyten fears that the present trend of science is to pursue mathematical computations in an experimental vacuum. On the contrary, it seems to me that recent developments furnish beautiful examples of the manner in which observation and theory are jointly, and inseparably, responsible for the progress of science. For example, the computations reviewed in my article provide a link between experimental nuclear physics and experimental elementary particle physics on the one hand, and observational astrophysics on the other: From experimental laboratory studies one obtains a fairly reliable understanding of the properties of matter at and below nuclear density ($\lesssim 10^{15}$g/cm^3). One then uses this laboratory-based knowledge, together with arbitrary assumptions about the equation of state of matter at supranuclear densities, and together with the theories of relativity and of hydrodynamics, to compute the properties of superdense stars, the dynamics of supernovae, and the dynamics of collapse to zero volume. Happily, one finds that, although the results of the computations are highly sensitive to the known properties of matter at subnuclear densities, they are insensitive to the unknown equation of state at supranuclear densities (*1*). From these experimentally based computations one concludes that supernovae, collapsing stars, and young superdense stars should all be copious sources of x-rays, of neutrinos, and of gravitational radiation. This conclusion provides an important impetus to the development of the very young, and as yet necessarily primitive, fields of neutrino astronomy and x-ray astronomy, and to the search for gravitational radiation.

The scope of observation, far from being decreased, is undergoing in the newer developments of astrophysics the greatest enlargment of this century. Everyone will agree with Luyten when he stresses that observation is the foundation of all knowledge; and everyone is excited by the new realms of observation which modern astrophysics is opening up.

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References

1. See, for example, C. W. Misner and H. S. Zapolsky, *Phys. Rev. Letters* **12**, 635 (1964); R. Penrose, *ibid.* **14**, 57 (1965); M. M. May and R. H. White, *Phys. Rev.* **141**, 1232 (1966); B. K. Harrison, K. S. Thorne, M. Wakano, J. A. Wheeler, *Gravitation Theory and Gravitational Collapse* (Univ. of Chicago Press, Chicago, 1965), chapters 5 and 11.

Quarks Defined

May I add a linguistic remark to Edwin M. McMillan's lecture on particle physics (27 May, p. 1210). McMillan states that Murray Gell-Mann suggested the name "quarks" for a possible set of particles, using a "made-up word originally used by James Joyce in an entirely different connection." In German the word quark is not a made-up word, but is the term for a somewhat gluey cottage cheese. Maybe the "hadrons" should be called quarks.

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