made by Rust of 200.

One place where Rust has erred is in the ΔT of the pressurized water reactor's steam generator. In a typical steam generator, the reactor coolant flow enters at 618.5°F, and leaves at 557.2°F, whereas the boiling temperature on the steam side is 544.6°F, corresponding to a pressure of 1000 psi. We deduce a mean driving ΔT of not more than 44°F, while Rust assumes a ΔT_{nuc} of at least 100°F. Further, it appears that the heat-transfer coefficient U_{nuc} is less than U_{ss}, presumably because of thermal impedance on the boiling side.

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Light sources for holography

I would like to elaborate on a point concerning holography made by Toraldo di Francia in his February article, which discussed the importance of the laser to holography (page 32). This light source is valuable not only for the off-axis method, but indeed for nearly all of holography. Our own experience indicates in fact that the laser source offers no particular bias in favor of the off-axis configuration. This new source offered reduced exposure time, ease of setting up interferometer configurations, and the possibility of holographing arbitrary, three-dimensional objects in reflected light. It did not, however, affect our development of off-axis holography. Our first published off-axis hologram (1962), a rather simple one, was made with the conventional mercury-arc source. In the ensuing year, we labored to perfect the process, and thereby produced the vastly improved and more complex results of our 1963 paper. The improvements came about by the use of better quality optical components and by improvement of techniques for avoiding the artifacts (dust, dirt, scratches, striations, and so on) on or within the various optical elements. At about the middle of this effort the laser became available, and we tried it. It offered no decisive advantages, and we shifted between the laser and the mercury source, uncertain as to which would best help us attain our goal. In the end we chose the laser, primarily because this permitted exposure time of seconds instead of minutes, and saved the bother of equalizing the reference beam and object beam optical paths. So far as image quality was concerned, there was little difference, except that the mercury source gave slightly higher quality.

The lack of any overwhelming advantage for the laser was of course a consequence of using transparencies for objects; the several-centimeter coherence length of the helium-neon gas laser was quite unnecessary for this type of object, and indeed made the artifact noise worse. We noted in our 1963 publication that the laser, though helpful, was not required, and that we had achieved comparable results with mercury sources. We always had adequate coherence with the mercury source.

Later research demonstrated that, with proper interferometer arrangements, the coherence requirements of off-axis holography reduce exactly to those of in-line holography.

The great advantages of the laser became manifest when we advanced from transparencies to arbitrary, reflecting objects, and when B. J. Thompson and G. B. Parrent used the pulsed laser to holograph moving objects. These were accomplishments that, so far as I know, cannot be carried out with the classical coherent sources.

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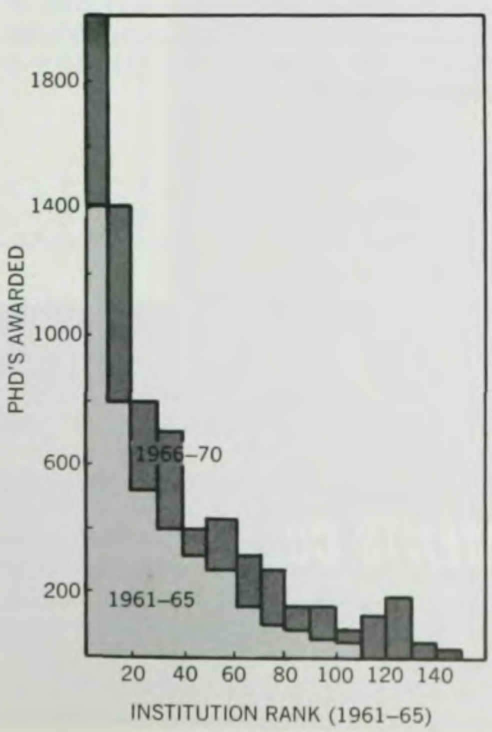
PhD production

We find it regretable that such a fine article as that entitled "Physics in Perspective" (July 1972, page 23) by D. Allan Bromley should give such a distorted view concerning the changing patterns in PhD production. Not only is the semi-logarithmic plot given in figure 3 misleading, but more important, the caption is in our opinion incorrect. Most of the "leading" institutions did not realize until 1969 or 1970 the seriousness of the employment situation, and it was at this time that



cuts in the size of enlarging graduate classes were made. Certainly the seriousness of the employment plight was not realized in 1966, and this would have had to have been the case if the caption for figure 3 were to be accurate. In fact, from the data of figure 3, it can be seen that the total increase in PhD production of the "leading" 30 departments is about the same as that of the remaining 120 departments combined. The figure on page 63 of the same issue also indicates that the caption we refer to above is incorrect. Students have not simply gone to lower-ranked institutions, but there has been an overall drop in physics enrollment as illustrated by the figure on page 63 and the 1971 annual report of the American Institute of Physics.

We hope that Bromley and the other members of the Physics Survey Committee will review the attached graph, which plots their data on a linear scale and will perhaps revise their viewpoint on patterns of PhD production in the United States over the last few years.

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Magic cosmic numbers

Referring to the article "Cosmic Numbers" by Edward R. Harrison (December 1972, page 30), we would like to call your attention to a few more coincidences that may help understanding of some magic in the list of magic numbers. Abdus Salam has proposed the idea of *strong gravity* in order to introduce a natural cutoff in hadron physics. What we consider worth mentioning are coincidences associated with the coupling constant of *strong gravity*. Let us take four different lengths: the Planck length $1 = (\hbar G/c^3)^{1/2}$, the Schwarzschild radius $a \doteq 2Gm/c^2$, the gravitational Bohr radius $r = \hbar^2\text{-}(Gm^3)$ and the Compton wavelength $\lambda = \hbar/(mc)$. These lengths are made up of three of four basic quantities $\hbar$, c, G and m. Now notice that the magnitudes of all four, evaluated for a nucleon, fall in the order of the nucleon size if one replaces the Newtonian gravitational constant G by the *strong* constant $G' = NG$. Here N is equal to N_1'' of Harrison's article: $N = \hbar c/(Gm_N^2) = 1.6 \times 10^{38}$, which corresponds to the ratio of the strength of nuclear forces to gravitational forces. This magic is however not all surprising insofar as the replacement of G by G' is legitimate. With the present choice of N the nucleon mass is identical to the Planck mass defined with G': $m_N = (\hbar c/G')^{1/2} = m_P'$. Hence all the lengths defined above with G' reduce upon elimination of G' to the nucleon Compton wavelength: $l' = (\frac{1}{2})a' = r' = \lambda_N$. The very trick of the magic must therefore lie in the seemingly active function of strong gravity in the small dimensions. Both kinds of the Planck length and mass are related by $l' = \lambda_N = N^{1/2}l$ and $m_P' = m_N = N^{-1/2}m_P$.

Harrison has the formula $R = [3c^2/(8\pi G\rho)]^{1/2}$ for the radius of a closed universe in its maximum expansion and suggests adopting the radius as a cosmic yardstick. It is interesting that the same formula with the nucleon density predicts the size of neutron stars. We would also like to point out that the replacement of G by G' again works for deriving $R_S/R_N = N^{1/2}$. For $m \approx 4\pi\rho R^3/3$, there follows the relation $R \approx Gm/c^2$, which Eddington used for estimating the radius of the universe. This relation has been tested for the Planck mass with G and for the nucleons with G'. It is reasonable for neutron stars as well. We wonder if Eddington's conjecture would be part of the grand rule underlying in the cosmic hierarchy.

Finally we observe that the normal gravitational Bohr radius of nucleons becomes roughly the size of the universe, while the strong Bohr radius coincides with the nucleon Compton wave length. This coincidence may be simply accidental. If, however, it is significant, the cosmic number $N_2 = R_U/R_N$ must be identical to N. Introducing the angular momentum $J = mRc$, we derive with Eddington's relation the following expressions: $m = (Jc/G)^{1/2}$ and $R = J^2/(Gm^3)$, which correspond to the Planck mass and the Bohr radius, respectively. The last coincidence could then be a consequence of another grand rule of quantization: $J = N^n\hbar$ ($n = 0$ for nucleons, $n = 2$ for neutron stars, $n = 5/2$ for galaxies and $n = 3$ for the universe).

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In his article Harrison points out that the number $N \approx 10^{40}$ can be obtained in several different ways. He concludes that, since we do not know how to "bootstrap" together microscopic and macroscopic realms of physics, "Each of us according to his own inclination is therefore free either to dismiss the coincidence as fortuitous, or to think that the coincidence is evidence of an underlying grand design in the structure of the physical world."

I would like to point out that this number emerges quite naturally in my

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