LETTERS

Proponents of Colliding Cosmologies Take Exotic Turns

While appreciating the past contributions of Geoffrey Burbidge, Fred Hoyle, and Jayant Narlikar, I take exception to their criticism of the scientific philosophy and method employed by the supporters of Big Bang cosmology ("A Different Approach to Cosmology," PHYSICS TODAY, April, page 38).

The authors criticize "mainstream" cosmology because the simple extrapolation of the universe to earlier times implies physical conditions that are not found in the current universe. Yes, this means there will be some new parameters and initial conditions that will have to be fixed by astronomical or particle physics measurements. But such complications pale in comparison with what the authors are prepared to introduce to avoid the simple extrapolation that is at the heart of Big Bang cosmology—namely, a new term in the cosmological equations, exotic dust grains, an unspecified method for stellar production of deuterium, and, most important of all, the need for two simultaneous interpretations of each of three phenomena: quasar redshifts, the power source of active galactic nuclei, and galaxy velocities in clusters. In each of these three cases, a single explanation will suffice for Big Bang cosmology, which therefore has the philosophical advantage in terms of Occam's razor.

The authors also rely heavily on what appear to be anecdotal cases of quasar positioning and jet alignment. If these alignments are statistically significant (when considering unbiased populations of both quasars and galaxies), a brief summary of the relevant analyses might have made the authors' argument persuasive. As written, the article gives the appearance of employing a very selective set of data, so that the conventional interpretation of quasars seems to have the philosophical advantage in terms of rigor.

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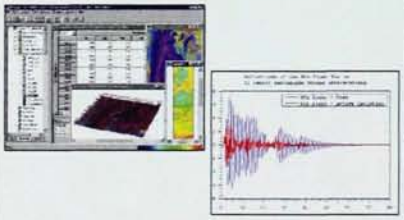
Letters submitted for publication should be sent to Letters, PHYSICS TODAY, American Center for Physics, One Physics Ellipse, College Park, MD 20740-3843 or to ptletter@aip.org (using your surname as "Subject"). Please include your affiliation, mailing address, and daytime phone number. We reserve the right to edit letters.

Geoffrey Burbidge, Fred Hoyle, and Jayant Narlikar claim to provide an alternative explanation for the origin of the cosmic microwave background and the production of helium-4. They point to the coincidence that, if all the ^{4}He in the universe had been produced in the stars (with an energy yield of about 6×10^{18} ergs for each gram of helium formed), then the accompanying radiation background should have an energy density of 4.37×10^{-13} erg/cm^3, which is quite close to the observed energy density of the microwave background—that is, 4.18×10^{-13} erg/cm^3.

The above figures imply a mass density of ^{4}He produced of 7.5×10^{-32} gm/cm^3, or about 10^{-8} atoms/cm^3 of ^{4}He. However, if all the ^{4}He is produced in this manner, then either the carbon-nitrogen-oxygen (CNO) cycle or the proton–proton (P-P) chain reaction (the main stellar processes for helium production) also implies that, for each ^{4}He nucleus produced, two electron neutrinos are also released. These neutrinos would have an energy of around 1 MeV for the CNO cycle and of about 0.4 MeV for the P-P chain. In the CNO cycle, the decays of nitrogen-13 and oxygen-15 each produce a neutrino. Thus, we would expect a near-MeV, electron neutrino background with a density of 2×10^{-8} ν_e/cm^3. This measure is comparable to the combined (integrated) background expected from all supernovae of type II (in which most of the binding energy of a neutron star is released in MeV neutrinos and antineutrinos of all flavors).

In the standard Big Bang picture, though, the expected neutrino background is completely different. According to this scenario, the neutrinos would have been in equilibrium[1] with other particles during the lepton era at MeV temperatures and then would have been decoupled as the universe expanded. Their present temperature

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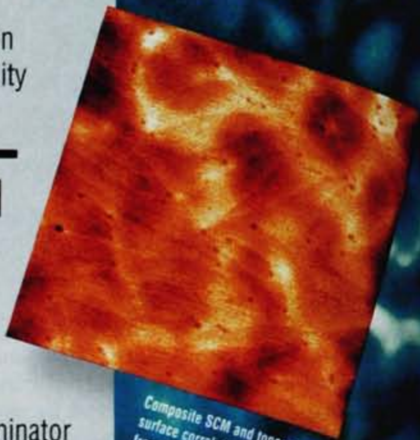

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*Sample courtesy A.P. Shilov, Moscow State University. 25μm

Background: MFM image of a $Fe_{80}B_{16}Si_4$ ribbon revealing stress-induced magnetic structure that can lead to power losses in electrical transformers, 30μm scan courtesy M.E. Hawley, Los Alamos National Lab

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would be around 2K, implying a number density[1] of around 150/cm^3 for each flavor (with individual energies of around 10^{-4} eV, or 10^{-10} MeV). However, if the neutrino were to have a small mass of around a few electron volts, this Big Bang neutrino background could dominate cosmological dynamics and, by clustering around galaxy halos with densities of about 10^6/cm^3 or more, could account for the missing mass in spirals.

By contrast, in Burbidge and company's alternative scenario, in which it is assumed that all the ^{4}He was produced in the stars, the neutrino background mass (energy) density would be at most of order 1 eV/cm^3, at least three orders smaller than in the Big Bang scenario. Here, the implication is that, under this alternative picture, neutrinos cannot constitute the dark matter in any way. If future experiments on the detection of dark matter are able to detect the 2K thermal neutrino background (with a density of a few hundred per cubic centimeter), they will provide clear-cut, unambiguous proof for a hot density early (MeV) phase, which—unlike the presence of the photon microwave background and ^{4}He—cannot be explained by Burbidge and company's different cosmology.

Reference

1. See, for example, E. W. Kolb, M. S. Turner, *The Early Universe*, Addison-Wesley, Reading, Mass. (1990), chap. 5.

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Burbidge, Hoyle, and Narlikar reply: David Smith makes it sound as though "mainstream" cosmology has the merit of simplicity when compared with our quasi-steady-state cosmology (QSSC). The difference can be explained as follows.

In physics as it is usually presented, all particles and all fields have positive energy densities. Physical processes subject to the normal conservation laws consist of shuffling one form of positive energy into another. As long as one confines oneself to such processes, the universe as a whole must arise in a Big Bang. Then, all the positive energy of the universe has to be created by arbitrary fiat all in a moment, which is usually taken to be about 10^{-33} seconds. The arbitrary fiat breaks the conservation laws in the most flagrant possible manner at the Big Bang, since all the positive energy of the universe has to appear from somewhere else at that moment. If, however, one postulates the existence of a negative energy field, that all changes. The positive energy component of physics can then be created along with the negative energy field without needing to break any conservation laws. This is the possibility that we have investigated. We believe that explosive events in active galactic nuclei (AGN) and quasistellar objects are evidence of the existence of such a field, as is the expansion of the system of galaxies.

As for what Smith sees as our dependence on "exotic" particles and on an "unspecified" source of deuterium, while the dust grains that we invoke may be exotic to Big Bang supporters, they do exist in the laboratory as whiskers that are well known to metallurgists. And deuterium is known to be produced by neutrons captured by protons in solar flares. There are many G-type stars like the Sun in the universe, so that the production and ejection of deuterium in stellar flares are extremely likely.

With respect to the associations of quasistellar objects with low-redshift galaxies and other evidence for physical connections between systems with different redshifts, the evidence is not, as Smith claims, "anecdotal." Study of the many papers quoted in our article[1] makes it clear that there are a large number of investigations, both statistical and morphological, that show that many quasistellar objects with large redshifts are physically associated with low-redshift galaxies.

C. Sivaram argues that in our development of an alternative to Big Bang cosmology, the expected neutrino background has an energy density much smaller than that of the microwave background, whereas in Big Bang cosmology the two are comparable. This statement is correct, but only if there is no production of energetic neutrinos in AGN and quasistellar objects, which is possible but uncertain. A measurement of the neutrino background at different energies may provide a means of testing these two alternatives. However, QSSC does not require any significant nonbaryonic dark matter, although it can accommodate such matter. The more likely candidates for dark matter in QSSC are very low mass stars, brown dwarfs, or burnt-out stellar remnants or massive objects, all of which are baryonic and are known to exist.

Surely what is truly "exotic" is the nonbaryonic, cold dark matter widely invoked by Big Bang cosmologists solely to make various parts of their models work!

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Reference

1. For example, G. Burbidge, Astron. Astrophys. **309**, 9 (1996).

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Cosmology Addendum: A Turner for the Better and a Web Cite

I would like to correct an error and an omission in the bibliography of my article, "Reply to 'A Different Approach to Cosmology,'" which ran in your April issue (page 44). Reference 3 should have read "E. Turner" (not "M. Turner"). Also, I should have cited an interesting 1994 exchange between Edward Wright (astro-ph/9410070) and Fred Hoyle, Geoffrey Burbidge, and Jayant Narlikar (astro-ph/9412045), which is available on the Web from the Los Alamos preprint archive (http://xxx.lanl.gov).

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Dual-Career Couples Can Trouble Students

Your article "The Dual-Career-Couple Problem" (July, page 32) deals with many aspects of the two-professional couple in academia. But the authors fail to address the problem from the student's point of view. Whenever a husband-and-wife team teaches in the same institution, a conflict of interest is inherently created. What if a student performs poorly or has a personality clash with the teacher in one course, and then has to take a course offered by that teacher's spouse? Such a situation can lead to a clear disadvantage for the student. Although the student actually may do well in that second course, the teacher's normal reaction to what had happened in the first course would almost certainly bring extraneous factors to bear on the student's grade. Of course, one cannot blame the teacher for reacting like that.

I know whereof I speak, because I once had to deal with a situation in which the wife was a terribly dull teacher for a terribly dull required course, and the husband taught a more advanced course that was also required. Because I did not tolerate the dull course well and the wife was upset with me (although I earned A's), I was penalized in the advanced course by the husband for having upset his wife. He denigrated me in class and gave me one-grade reductions (to B's).

Because of the clearly unavoidable conflict of interest in such cases, married couples should not be allowed to teach in related departments, possibly not even at the same academic institution. The prohibition should probably extend to teachers who start dating each other, since the same conflict will immediately arise.

The institutions of higher learning are supposedly funded from the public trough because they exist primarily for the general benefit of students and for training our future scholars and intellectual leaders, not to provide an easier life for dual-career couples. If the interest of the students really is paramount, an institution should hire the one member of a couple that it wants. If it also wants to help find the other spouse a job, then it should do so, but at another institution or organization.

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MCNEIL AND SHER REPLY: Robert Dennis had a bad experience with a single couple, and received B's instead of the A's he thought he deserved. Complaints from students about "unfair" grades are common, but Dennis's solution to the "problem" is more drastic than most. Based on his view of a single incident, he wants to force thousands of scientists, primarily women, to give up their careers. We are reminded of those employers who refuse to consider female candidates because "We hired a woman once, and it didn't work out."

He even goes further and wants to dismiss faculty members who begin dating one another. Besides the obvious legal difficulties of an institution restricting the social life of its employees, the realities of small college towns limit the options of faculty members who are single. Since they certainly shouldn't date students, and Dennis doesn't want them to date faculty, what are they to do?

Nobody we know of has suggested that institutions of higher learning exist to provide "an easier life for dual-career couples." As we stated in the article, helping dual-career couples helps an institution by allowing it to attract and keep two talented professors. It certainly is not in the students' best interests to have faculty members leave because a spouse found a job elsewhere. Dual-career couples are generally closely tied to the academic community, which is good for students. Such couples also show students that they don't have to choose between career and family.

One of us (Sher) also had a difficult experience in college, when a professor was never available because his child was sick. He missed office hours and wasn't available before exams; it was not a good learning experience. Everyone agrees that faculty members with children have less time available to help students. Does that mean faculty members should be prohibited from having children?

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Oppie's Reputation as Leader Is Questioned

In his letter in your June issue (page 13), Ben Oppenheimer says of J. Robert Oppenheimer that "it could be argued that his leadership on the Manhattan Project had been paramount in safeguarding this country's interests during World War II." But it also could be argued that Robert Oppenheimer had little to do with the scientific leadership that produced the A-bomb. The decisions to build the weapon and to use it were both presidential decisions. Scientists played advisory and enabling roles that were critical to the successful design and production of the weapon, but it is arguable as to which scientists were critical to that achievement.

One clearly essential breakthrough was Enrico Fermi's demonstration of a fission chain reaction in Chicago in December 1942. The steps from there to the bomb were, at least in hindsight, matters of scaling and design, to be mastered by competent engineering. Yet Oppenheimer was not even remotely an engineer. In fact, Fermi and Oppenheimer present such a contrast in scientific and personal qualities as to make them models for students of the sociology of science generally.

Fermi was the brain, heart, and soul of any scientific team of which he was a member. He was equally proficient in theory and experiment. That, combined with a natural charm, modesty, and willingness to