

system. The assertion that single crystal silicon solar cells may be too expensive for use in the SPS is moot, because more advanced photovoltaic materials such as thin-film solar cells are projected to be available by the end of this decade ("Aerospace Power Systems," R. R. Barthelemy and D. J. Curtin, *Astronautics and Aeronautics*, July/August 1981, page 71).

The OTA report correctly concludes: "The total costs estimated by NASA included major elements, such as space transportation and photovoltaic cells, whose development is likely to proceed regardless of SPS; these costs should not be charged solely to SPS." There is no basis for projecting the costs of an SPS system to be constructed during a period from 20 to 50 years without accounting for the evolution of advanced technologies, including low-cost efficient space qualified solar cells; low-cost space transportation systems from Earth to low-Earth orbit, and from low-Earth orbit to geosynchronous orbit; space construction techniques; and technologies associated with the transmission of power from space to Earth.

Both reports acknowledge that the evaluation of environmental effects and their mitigation will continue to be a priority for research. For example, the synergistic effects of SPS development on space industrialization could include the utilization of extraterrestrial resources and contribute to the economic justification for developing facilities for mining and refining lunar materials, and designing an SPS adapted to the use of lunar materials so as to minimize the space transportation requirements of terrestrial materials to geosynchronous orbit and thereby reduce deposition of rocket effluents in the atmosphere. This could be accomplished after a limited number of SPS's have been constructed and demonstrated to be of potentially global benefit.

The institutional and societal challenges of an SPS program are being widely recognized, and will be discussed at a plenary session planned for the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space, to be held in Vienna, Austria, in August 1982.

In Robert Goddard's words: "It is difficult to say what is possible, for the dream of yesterday is the hope of today and the reality of tomorrow." On the basis of existing information, research on the issues associated with the SPS can be justified in the broader content of an international SPS development as a major option for meeting future energy demands.

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## Hiroshima, revolution & physics

Spencer Weart's "The Last Fifty Years—A Revolution?" (November, page 37) recalls interesting details of the early popular enthusiasm for radioactivity. He then asserts that a reversal of that attitude "can be dated very precisely. It was caused by Hiroshima." No documentation is given.

In evaluating the causative role of Hiroshima, it is necessary not only to take account of many pre-Hiroshima events which caused concern about the health aspects of radioactivity, but it is also essential to take account of the role played by Hiroshima as a tool of political propaganda, particularly by the Soviet Union when it felt threatened by our nuclear monopoly.

Lest we swallow propaganda whole, we must recall clearly the military realities which made the Hiroshima decision a life-saving one for Americans and for Japanese.<sup>1</sup> We must resist the re-writing of history which maligns the intentions and actions of our wartime leaders, and we must resist the misleading sloganeering associated with "Hiroshima." Physicists have a special obligation to keep the Hiroshima record straight.

Another point in Weart's account to which exception must be taken is his reference to Lenin and the Russian Revolution in a context in which "Revolution" is used consistently in a laudatory way. It has probably been used that way since Copernicus' "De Revolutionibus..." made "Revolution" a metaphor for intellectual and social advance. If so, it is a particular concern of physicists that the word be used with care. Hence, if we recall that Lenin destroyed the constitutional, elected regime of Kerensky, which itself represented a "Russian Revolution," with a regime marked by dictatorship, terror, mass-liquidations, Gulag, and so on, it would have been more appropriate to refer to Lenin's "Russian counter-Revolution."<sup>2</sup>

Since Newton and the Enlightenment, physics and physicists have played roles of model and standard-setter for all the empirical sciences. That role has been and remains one of our proudest functions as physicists. There is no reason to believe that role has been played out despite its frequent abuse and neglect. Perhaps the next retrospective view of physics will show how its influence has extended far beyond its immediate jurisdiction as a model of achievement in empirical science—a model in which concern for precision and accuracy play a vital role.

### References

1. Paul Fussell, "Hiroshima: A Soldier's View", *The New Republic*, 22 & 29 Aug. 1981, pp. 26-30, and the exchange with

M. Walzer, 23 Sept. 1981, pp. 13-14.

2. See, for example, Robert Solo, "Economic Organizations and Social Systems", Bobbs-Merrill, New York, 1967, who refers to the communist revolutions of Russia and China as "palace coups."

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THE AUTHOR COMMENTS: I thank Lawrence Cranberg for drawing my attention to points where my article was ambiguous. For brevity I used catchwords to stand for complex historical processes, and neglected to recall that such words can mean far more, to some people, than I intended. Regarding "Hiroshima," in my article I did not deplore (nor praise) the decision to drop atomic bombs. I meant to say in a word that since 1945 it has been clear that these weapons exist and can be used. This fact has deeply affected public views of physics; I am working to publish the documentation of that complex development as soon as I can.

Regarding my statement that the great change in physics concepts during 1881-1931 was roughly analogous to the way "Lenin's generation had upset the social structure of Russia," perhaps if I had written, "the generation of 1919..." I would have avoided triggering irrelevant political thoughts. I trust that if enough care is used, the word "revolution" can still be used in each of its separate traditional senses in science, politics, and astronomy, and that the traditional analogies can still be drawn, without misleading readers.

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2/82

## Does the universe expand?

Recently an exchange of letters on  $G$ -variability appeared (August, page 11). This note is aimed to initiate a discussion on a no less important subject: the hypothesis of the expanding universe. A few arguments will show that time is ripe to reconsider the justification of this hypothesis:

► The latest determinations of the values<sup>1</sup> of  $H_0$  (100 km/sec Mpc, which gives  $H_0^{-1} = 9.8 \times 10^9$  y) and<sup>2</sup>  $q_0$  ( $\approx 2$ ) result<sup>3</sup> in the following age of the universe:

$$T_0 = H_0^{-1} q_0 (2q_0 - 1)^{3/2} \times [\cos^{-1}(1/q_0 - 1) - (1/q_0)(2q_0 - 1)^{1/2}] = 4.5 \times 10^9 \text{ y}$$

which is incompatible with the ages of the oldest systems known:  $(1.5-2.0) \times 10^{10}$  y. A favorite method of avoiding such discrepancies consists in reducing the above values. Lebofsky<sup>4</sup> deduced  $q_0 = 0.05$  by restricting the sample of galaxies to those with  $z < 0.5$ . Carney<sup>5</sup> required the value of  $H_0$  to be