Comment on "Is Proton Decay Measurable?"

The recent paper by Horwitz and Katznelson[1] discusses the effect of frequent observations on the time development of a decaying state, and applies this in particular to the problems of proton decay inside a nucleus. It is indeed easy to see from the usual derivation of Fermi's golden rule, that the exponential law of decay takes over only after some minimum time t_1 if an observation has ascertained that at time 0 no decay had yet taken place. The paper also correctly estimates t_1 for the case of proton decay to be of the order of a few times 10^{-23} sec. It follows that periodic monitoring of the decay with a period of this order would affect the decay rate. It is also clear that experimentally such closely timed observations would not be very practical, particularly as the decay products would move in that time only a few femtometers from the source.

The paper claims, however, that collisions within the decaying system are equivalent to observations. There is no justification for this claim. The decaying system consists of all the initial particles, including all their interactions, and the initial state is an eigenstate of the complete Hamiltonian, excluding only the coupling which is responsible for the decay. (Some decaying states do not allow the Hamiltonian to be divided into a part with stationary eigenstates and a part responsible for the decay, but they can be discussed in an appropriate way,[2] and again internal collisions are included.)

The authors have not established that collisions are equivalent to observations (though they can become an element in an observation, if the collision is followed by an observation on the particles with which the given one has collided).

It is of course well known that interactions can affect the decay rate. This happens, for example, in ordinary β decay, where, for a low decay energy, the transition might become "forbidden" and thus the rate might become less in order of magnitude than that of a free neutron.

This can happen when only one, or a few, states of the final nucleus are energetically accessible, and have the wrong symmetry. In the case of proton decay, when the energy release is of the order of 1 GeV, it seems certain that this will include many states of the final nucleus or its fragments, including many of suitable symmetry. We conclude that this effect—which is quite distinct from the one invoked by the authors of Ref. 1—is not likely to contribute more than a numerical factor of order unity.

We conclude that there is no reason to revise the predictions for proton decay substantially.

John Wheater
Department of Theoretical Physics,
Oxford University
Oxford OX1 3NP, England

Rudolf Peierls
Department of Nuclear Physics
Oxford University
Oxford OX1 3RH, England

Received 20 May 1983
PACS numbers: 14.20.Dh, 12.90.+b, 13.30.Ce

[1] L. P. Horwitz and E. Katznelson, Phys. Rev. Lett. 50, 1184 (1983).
[2] G. García-Calderón and R. Peierls, Nucl. Phys. A265, 443 (1976).

© 1983 The American Physical Society