and dyes. As one of the companies involved in the production of nuclear fuel for potential German weapons, the Auergesellschaft also figured in the report of the Alsos Mission, led by Goldhaber's colleague Samuel Goudsmit. After the war, the company was taken over by Degussa.

The health benefits of Doramad were touted on the toothpaste tube: "Its radioactive radiation increases the defenses of teeth and gums. The cells are loaded with new life energy, the bacteria are hindered in their destroying effect. This explains the excellent prophylaxis and healing process with gingival diseases. It gently polishes the dental enamel so it turns white and shiny. Prevents dental calculus."[1]

Maurice Goldhaber never forgot that I grew up using radioactive toothpaste.

Reference

1. http://www.orau.org/ptp/collection/quackcures/toothpaste.htm.

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■ **Alfred Goldhaber and Maurice Goldhaber** presented a convincing case for not trying to observe helicity reversal in relativistic neutrinos (Physics Today, May 2011, page 40). However, I was disappointed that they did not discuss the nonrelativistic Big Bang relic neutrinos. Their low energy precludes detecting them today, but their natural abundance and the existence of clever people make me suspect observation is possible in the near future. Helicity reversal effects may provide a key for this elusive search.

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■ **Goldhaber replies to Esterling:** As Bob Esterling implies, the challenge here is not producing reversed helicity but *observing* it: Reaction rates are tiny because of low neutrino density and small cross sections. Absent an independent calibration of neutrino density, there would be no characteristic signal of helicity reversal for Dirac neutrinos. If production of relic Majorana neutrinos were associated mostly with matter rather than antimatter, neutrino helicity equipartition still could lead to nearly equal production of electrons and positrons—a striking signal *if* it could be seen.

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Preserving quantum nondemolition

A new concept appeared in the literature of quantum physics in the 1980s, under the name of "quantum nondemolition [QND] measurements."[1] The idea quickly became very popular, and it is now used in many contexts, with a wide agreement about its meaning and usefulness.[2–4]

However, Christopher Monroe argued in a letter to Physics Today (January 2011, page 8) that QND measurements are a useless concept because they are just standard quantum measurements, as defined, for example, by John von Neumann at the dawn of quantum mechanics. Here I argue that this view is too schematic, to say the least.

Measuring the polarization of a photon—a representative quantum measurement—typically destroys the photon. The simple but crucial question addressed by QND measurements is the following: Is it possible to perform a quantum measurement in such a way that the system will continue to exist even though its state may be altered by the measurement that has been performed? The answer is yes, but one has then to use an indirect measurement rather than a direct one, and that is exactly where QND measurements come into play[1,2]—in quite a useful way.

For such a measurement to work, the trick is to use an auxiliary quantum system, usually called the "meter," and to devise the system–meter interaction in such a way that entanglement is created between the two. Then a direct measurement performed *on the meter* will result in a projective measurement on the system. Therefore, the system will evolve into a post-measurement state as expected, but it will not be demolished; hence the name quantum nondemolition.

The crucial role of the meter was already pointed out by von Neumann in the 1930s, but QND gives conditions for the measurement chain—entanglement, direct meter measurement, projecting the system onto the final state—to work properly.[1] For instance, the interaction Hamiltonian between the system and the meter should commute with the system observable to be measured. In addition, various QND criteria have been introduced to characterize the quality of such measurements.[2] Those criteria are useful tools to quantify the success of a real QND measurement; they are actually quite flexible and may be adapted to any given experimental situation, with continuous[2] or discrete[3,4] observables.