script in *Physical Review Letters* in 1965 (*Phys. Rev. Lett.* **14**, 380, 1965), at which time the velocity-dependent terms and our regularized meson fields that enabled us to treat S waves were still novel features among the then-evolving one-boson exchange models. In subsequent N–N studies [*Rev. Mod. Phys.* **39**, 594 (1967)] we worked towards implementing a fully relativistic treatment and finally succeeded [*Phys. Rev. D* **3**, 2076 (1971)], but found results in the 0–300-MeV region very similar to those obtained with a Schrödinger–Pauli treatment. However, in Dudley's PhD thesis on the N-nuclear problem using the Dirac equation, with the same scalar-vector meson fields, we could fit many observed nuclear properties with a minimal adjustment of parameters.

It might be noted that the cancellation of the major terms in a scalar-vector model of N–N or N-nuclear interactions suggests that at low energies the nuclear force should be characterized as a "moderate" force rather than a strong force. The strong force is manifested in the relativistic terms in scalar-vector theory as $v^2/c^2 \rightarrow 1$ and also in N–$\bar{N}$ studies, where the scalar and vector static terms add rather than cancel.

I hope these comments and this background add to your informative news item.

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Nonrelativistic spin

The news story "Relativistic treatment of low-energy nuclear phenomena," which appeared in March (page 20), contains a misstatement concerning the relationship between spin and relativity. We see there the assertion that "Spin is, after all, an intrinsically relativistic phenomenon." That this is not the case was clearly demonstrated[1] by Lévy-Leblond in 1967.

In his paper, Lévy-Leblond treats the Schrödinger equation the way Dirac treated the Klein–Gordon equation, seeking an equivalent differential equation that is first-order in the derivatives. As in the relativistic case, a four-component wavefunction emerges and transforms under rotations according to the direct sum of two spin-½ representations of the rotation group. (In the nonrelativistic case, the negative energy solutions are absent: Two of the four components are no longer independent.) Furthermore, Lévy-Leblond shows that when electromagnetic interactions are introduced, the Landé g-factor is equal to 2, just as in the relativistic case. Thus spin-½ particles emerge just as naturally in Galilei-invariant quantum mechanics as they do in the Poincaré-invariant case. Spin is not "an intrinsically relativistic phenomenon."

I hope that these results will become better known throughout the physics community, not only because of their fundamental interest but also because of the insights that they might yield in understanding phenomena that lie in the grey areas between the so-called "nonrelativistic" and "relativistic" domains.

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Long-time tails

In your interesting issue on Nonequilibrium Fluids (January) B. J. Alder and W. E. Alley and E. G. D. Cohen stated (or, at least, implied strongly) in their respective articles that the so-called "long-time tail" in the velocity autocorrelation function of an atom or a molecule in a liquid has not been observed experimentally. While this appears to be the case for atoms or molecules, the purpose of this letter is to point out that fairly unambiguous experimental evidence has been obtained recently for a long-time tail in the velocity autocorrelation function of spherical microscopic colloidal particles (diameter of order 1 micron) executing spontaneous Brownian motion in a liquid. These experiments were performed by dynamic light scattering, which measures the mean-square displacement of such a particle (in a suspension dilute enough that interactions between the particles can be neglected). Here the $t^{-3/2}$ long-time tail in the velocity autocorrelation function manifests itself as a $t^{1/2}$ term in the mean-square displacement.

The first such experiment was performed in 1976 by J. P. Boon and colleagues[1] who found indications of this $t^{1/2}$ term; however, their experimental error was not much smaller than the effect itself. Subsequently G. L. Paul and I studied[2] larger spheres (where the relative effect is large) and found clear evidence of the $t^{1/2}$ term. Here, however, the amplitude of the term was about $74 \pm 5\%$ of that predicted by the hydrodynamic theory outlined in the article of Alder and Alley. We emphasized that this discrepancy could well be caused by undetermined systematic errors in the experiments. Nevertheless, at about the same time, L. E. Reichl[3] suggested that consideration of rotational degrees of freedom in a suspending liquid composed of non-spherical molecules could modify the simple hydrodynamic theory. Most recently, however, K. Ohbayashi, T. Kohno and H. Utiyama have performed another dynamic light-scattering experiment[4] which again observed the $t^{1/2}$ term in the mean-square displacement having an amplitude that agreed with the simple theory within estimated experimental error (about 10%).

Thus, although the discrepancies mentioned above need to be resolved, I think one can claim that long-time tails have been observed experimentally. Of course a particle suspension is not a simple liquid, and unambiguous observation of a long-time tail in the latter remains an outstanding challenge to experimentalists. Nevertheless, the colloid experiments provide strong support for Alder and Alley's hydrodynamic picture of the long-time tail in a system where, because of the large difference in size between the particles and the liquid molecules, macroscopic hydrodynamics would be expected to apply.

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Interferometry: a bone to pick

Contemporary physicists are often so taken with their own accomplishments that the work of earlier researchers is sometimes ignored. Such is the case of a claim made in The article by James Underwood and David Attwood, "The renaissance of x-ray optics" (April, page 44). While the field of x-ray optics was generally well covered, the authors' discussion of x-ray interferometry was misleading. They claimed that Bonse and Hart "invented x-ray interferometry." This could not be farther from the truth and probably derives from similar claims made in articles by Bonse, and by Bonse and Hart, themselves.[1,2] Bonse and Hart did revolutionize x-ray interferometry with their invention of the monolithic Laue case device. However, the observation of x-ray interference patterns and the application of x-ray interferometry began more than fifty years ago.

Experiments to observe interference