ger cat. I'm more interested to see how far can we go to get macroscopic linear superposition of states. It's clear that you can see it in the microscopic scale, but on the macroscopic scale it's not obvious at all. You must have some intermediate distance where the transition is between quantum physics and classical physics."

Very recently the group has used the so-called adiabatic passage technique to transform the six wavepackets into a single wavepacket. Says Cohen-Tannoudji, "Here we are already at the macroscopic scale since the wavepackets are separated by distances of the order of one centimeter, and we still have a linear superposition of states. The fact that we are able to recombine the six wavepackets into a single one is an *a posteriori* proof that the six wavepackets are coherent." The adiabatic passage experiment was reported at the Laser Physics Conference held in Moscow in August.

This kind of adiabatic recombination of coherent wavepackets (involving just two wavepackets) was first demonstrated by a group at the University of Munich—Tilman Esslinger, Matthias Weidemüller, Frank Sander, Andreas Hemmerich and Hänsch, who used rubidium atoms. They reported their results at the Twelfth International Conference on Laser Spectroscopy held in Capri, Italy, in June.

Understanding the behavior of these subrecoil systems with very long interaction times requires the use of a new statistics, says Cohen-Tannoudji. The usual quantum optics methods become obsolete. He and his collaborators have analyzed subrecoil laser cooling in terms of Lévy flights,[6] which are anomalous random walks dominated by rare events.

Helium is an excellent atom for subrecoil cooling because it has a small mass that gives high recoil velocity, a simple level structure with two J=1 states, and a metastable state. The metastable atom carries so much energy that when it hits the detector surface, it acts like a microscopic bomb. The atom can be detected with close to 100 percent efficiency, so the experimenters can find exactly where and when it landed.

Leduc says the Ecole Normale group is tempted to try producing Bose–Einstein condensation in helium now that this condensation has been achieved in rubidium by Eric Cornell, Carl Wieman, Michael Anderson and their collaborators. (See PHYSICS TODAY, August, page 17.) "Because helium has two isotopes," Leduc said, "we could compare the statistical properties of both boson and fermion gases." The group might be able to study the competition between gas and superfluid behavior, she added, but that goal may be a distant one because it's not easy to start with a high density of metastable atoms.

The next experiment the Ecole Normale group plans is to have one helium wavepacket pass through a vibrating sheet of light. Thus a single de Broglie wavepacket will pass through a medium, introducing a modulated phase shift, the opposite to light passing through an electro-optic plate. The wavepackets would split into several components, giving rise to a splitting of the spot recorded by the detector.

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Oak Ridge Builds Facility for Radioactive Ion Beams

Oak Ridge National Laboratory has recently completed the construction of a radioactive ion beam facility to create nuclei at the limits of stability. The facility is now being commissioned. Created by reconfiguring two existing accelerators that have been used as a heavy-ion facility, the new Holifield Radioactive Ion Beam Facility is expected to be ready for experiments next summer. Because of the decreasing ratio of protons to neutrons for heavy stable nuclei, says Jerry Garrett, scientific director of the facility, the most efficient technique for producing proton-rich nuclei for nuclear structure studies involves heavy-ion induced fusion-evaporation reactions using proton-rich projectiles and targets with nearly equal masses. "This new facility should be well suited for such studies of proton-rich nuclei," Garrett says.

Over the last two decades, the ISOLDE facility at CERN has pioneered the use of radioactive ion beams, produced by bombarding a target with 600-MeV (later 1 GeV) protons and boiling off the radioactive ions. Those ions were then processed in the Isotope Separator On-Line facility. More recently the Cyclotron Research Center in Louvain-la-Neuve in Belgium has also operated an ISOL radioactive ion beam facility at energies below the Coulomb barrier appropriate for astrophysics measurements.

The new draft long-range plan of the Nuclear Science Advisory Committee says that the scientific opportunities provided "by world-class radioactive beams are extremely compelling and merit very high priority. The US is well-positioned for a leadership role in this important area. We strongly recommend the immediate upgrade of the MSU [Michigan State University] facility to provide intense beams of radioactive nuclei via fragmentation. We strongly recommend development of a cost-effective plan for a next generation ISOL-type facility and its construction when RHIC [the Relativistic Heavy Ion Collider at Brookhaven, scheduled for completion in 1999] construction is substantially complete." Construction of a major ISOL-type facility is estimated to cost a bit more than $100 million.

Thus, the Holifield Radioactive Ion Beam Facility will also serve as a prototype for the ISOL facility. In the reconfiguration, a high-intensity proton beam from the Oak Ridge Isochronous Cyclotron strikes a target, producing radioactive particles, which are ionized. They are then mass analyzed and reaccelerated by the 25-MV tandem electrostatic accelerator. Finally, the accelerated radioactive beam strikes a target where the reaction to be studied occurs.

The new $2.6-million facility is expected to be able to produce and study over a hundred new kinds of nuclei. It can produce beams above the Coulomb barrier (5 MeV per atomic mass unit for the heaviest species and 15 MeV/amu for the lightest species) for atomic mass less than 90.

The new facility will be used for studying the rapid proton capture process in nucleosynthesis and for studying nuclei far from stability, near the so-called proton drip line, where the nucleus becomes unbound and emits a proton.

In addition to Michigan State, other radioactive ion beam facilities that employ the projectile fragmentation technique are located at RIKEN in Japan, GANIL in France and GSI in Germany.

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