

Murray Gell-Mann — attacking deep issues.

(Photo Fermilab)



The success of any workshop or conference depends upon the planning and thought that goes into the organization, and on the participation. The Quantum Cosmology Workshop was fortunate to attract a large number of extremely talented people. After all, the aim was to try to find out why and how the Universe was created — not a subject for the faint of heart.

Part of the success of the meeting was the participation and contribution of Murray Gell-Mann. Recently, with Jim Hartle of the University of California at Santa Barbara, he has been attacking deep issues at the foundation of quantum mechanics which must be addressed in the context of cosmology. He opened the conference with the observation that 'crackpots do double damage to the fields they populate by spread-

ing misinformation and by preventing serious people from doing honest research.'

Quantum mechanics contains subtleties which are amplified as one delves into the very earliest instants of the Big Bang. In ordinary textbook quantum mechanics the state of a system is influenced by the observer; in the early Universe who plays the role of observer?

Gell-Mann and Hartle propose that this dichotomy between observer and system arises only when one restricts attention to a few of the infinite degrees of freedom of the world; indeed it is more than a practical necessity that one does so. Thus in any analysis of the early Universe as a quantum mechanical system in which one tracks a subset of the full infinite degrees of freedom there will be effective observers,

termed IGUs (Information Gathering and Utilization Systems) by Gell-Mann, acting to disturb the state of the system, but arising self-consistently within the larger framework of the infinite number of physical degrees of freedom.

Another notable contributor was Yakov Zel'dovich, one of the best-known and most respected of Soviet physicists. During his long and distinguished career in physics and chemistry he has made important contributions to the idea of a 'quantum birth' of the Universe. Along with Alexei Starobinsky (also attending), he presented a historical perspective of the important contributions of Soviet physicists to quantum cosmology.

One of the most original and talented minds in physics belongs to Stephen Hawking. Fermilab was lucky that Hawking's second visit to the Lab was during the Workshop. In addition to his talk, the workshop benefited from Stephen's deep and profound questions and observations. Hawking recounted that his discovery of the evaporation of black holes followed conversations with Zel'dovich. Hawking and Zel'dovich had much time together at Fermilab; perhaps something equally profound will result.

Neutron riches

One latter-day physics innovation at the venerable Berkeley Bevalac (which in its original Bevatron form came into action in 1954) has been the production of high energy beams of exotic isotopes. Produced when nuclear beams hit a target, the isotopes are filtered magnetically and further identified by velocity and electric charge measurements.

Japanese teams play a prominent role in this work, part of the fruitful Japan-US Joint Programme for High Energy Physics.

From measurements of the interaction rates of a range of these isotopes, physicists were able to deduce the effective nuclear radii.

While the properties of relatively stable isotopes agree with measurements made using electron beams, the very neutron-rich nucleus lithium-11 (three protons and eight neutrons) appears to be much larger than neighbouring isotopes, suggesting that something new is happening.

On the nuclear 'drip line', lithium-11 is saturated with neutrons and is the heaviest drip line nucleus yet studied in detail. In addition to the information from the Bevalac studies, lithium-11 properties (mass, decay modes, spin, magnetic moment) have been measured in experiments at CERN.

Back in 1972, A. Migdal of Moscow suggested that a pair of neutrons, although incapable of binding together unaided, could perhaps stick together when a nucleus is around. The small binding energy (190 ± 110 keV) of the final lithium-11 neutron pair, and the fact that lithium-10 cannot stick together, suggested to Gregers Hansen of Aarhus (presently at CERN) and Bjorn Jonson of Chalmers University of Technology, Goteborg, that lithium-11 could be looked at as a 'quasi-deuteron' with a lithium-9 core loosely coupled to a dineutron. (The deuteron, consisting of a proton and a neutron, is the textbook example of a loosely bound nucleus.)

According to this model, the weak binding brings about a 'neutronization' of the nuclear surface, with the lithium-9 core surrounded by a neutron halo. It is this halo

which pushes out the nuclear radius, and an estimate agrees with the value measured at Berkeley.

This suggests that other nuclei at or near the neutron drip line should show interesting behaviour. The nuclei are so loosely bound that even a very soft interaction would remove the neutron pairs.

Additional experimental information comes from the French GANIL heavy ion accelerator looking at the reaction rates of neutron-rich nuclei from carbon to magnesium. The GANIL work shows that the absorption radius increases rapidly with neutron excess rather than with atomic (proton) number.

This should also provide added research value for the SIS heavy ion synchrotron now under construction at the Darmstadt heavy ion Laboratory (GSI), scheduled to become operational in 1989, where a spectrometer for work with fast beams of radioactive ions is foreseen.

The projectile fragmentation mass separator planned with the SIS/ESR heavy ion complex now being built at the GSI Darmstadt Laboratory. It follows a scheme used first at the French GANIL heavy ion machine, with an initial magnetic field removing the primary beam, and an absorber introducing an additional nuclear dependence, so that the second dipole can select specific nuclei.

DETECTORS

High resolution streamer chamber

The production of particles containing heavy quarks using hadron beams presents severe challenges because of the low production rates and the topological complexity of the events. These problems are especially severe in the hadro-production of 'beauty' (b) quark systems where production rates are about one part per million of the total interaction rate and a typical event has five separate interaction vertices.

A promising approach is the use of a streamer chamber with a setting error (per streamer) of some ten microns and a two-track resolution in the 30-50 micron range. Such a chamber would serve as triggerable high resolution vertex detector with excellent pattern recognition and high rate capability. Even with conservative assumptions about the production rate, samples of 500 B meson pair events per experiment appear reasonable. The topological reconstruction capabilities of the streamer chamber would mean that nearly

