Niels Bohr

# Centenary revives old questions

*Copenhagen*

THE eight hundred or so who gathered at the Niels Bohr Institute last week to celebrate the centenary of Bohr's birth were united in their awe and admiration of the quantum theory, which they agreed has been colossally successful at every level that it touches. Yet the gathering also vividly showed how the old questions, mostly first asked by Bohr himself, continue to haunt those who think about the quantum mechanical description of the world.

Anthony Leggett of the University of Illinois put the dilemma clearly. "By day, you can see me sitting at my desk solving Schrödinger equations and calculating cross-sections just like any other physicist. But occasionally, at night . . . I question whether quantum mechanics is the complete and ultimate truth about the Universe . . . Worse, I am inclined to believe that at some point between the atom and the human brain, the superposition principle must break down."

But even those who marvel at the theory Bohr built do not suggest that the limitations of quantum theory have been fully explored. Does quantum mechanics, successful on the scale of one or a few atoms, function when there are large numbers of them? Schrodinger's paradox of the cat in a box reappeared last week, but in a refined form. The cat may be in one of two states, alive or dead, and in the absence of information one way or the other must be assumed to be in a superposition of the two But when the box is opened and the cat observed, only one state *i* is possible.

The underlying question is whether the essence of the quantum mechanical description, the superposition of states, does carry through from the microscopic to the macroscopic. Leggett last week described a superconducting ring containing a Josephson link that may be used to test the issue. Current can flow in one direction or the other, but can it be said to be flowing in both directions at the same time? Leggett's subversive hope is that "common sense" will prevail, in which case quantum mechanics will have to be adjusted for large numbers. But most last week held that common sense would fail and quantum mechanics triumph: the experiments of Aspect and his colleagues, the argument goes, have already shown that, at the microscopic level, one cannot talk of a "real" world independent of the observer without breaking the barrier to the velocity of light.

That would have delighted Bohr, but he would have been surprised at the degree to which arguments involving symmetry, and symmetry-breaking, have become features of physical explanations. Philip Anderson (Princeton) applied the notion to the nature of the measurement process, while Robert Schrieffer (Santa Barbara) showed how symmetry-breaking leads to fractional quantum numbers in systems as different as electrically conducting polyacetylene, two-dimensional heterojunction semiconductors and the Bose–Dirac fields of relativistic field theory.

Symmetry, or symmetry-breaking, comes into its own in particle physics, of which Sheldon Glashow (Harvard) gave a characteristically racy account. The quarks and leptons which seem to be the fundamental particles of our world, and the characteristic forces between them, are the consequences of a broken symmetry obtaining at an earlier stage of the Universe, when characteristic energies were greater than now.

The cloud hanging over particle physics, Glashow said, is the very success of the "standard model" built up in this way. There are no contradictions, no loose ends and no hint of structure below the quarks and the leptons now recognized. And recently there has also been a dearth of surprise. From the 1930s to the 1970s, each decade saw the discovery of unexpected particles, but this decade (so far) has seen only the discovery of the W and Z particles — a "fantastic achievement, but not a surprise".

Indeed, in Glashow's view, the characteristic of this decade is the list of missing surprises — magnetic monopoles, neutrino oscillations, free quarks, proton decay, unpredicted particles and the like. Maybe, Glashow teased, the subject has become like medieval scholarship, with experimenters endlessly refining (like the alchemists) ancient techniques in their search for the exotic, the theorists (or theologians) in a realm based on faith where all things of interest are inaccessible (with particle accelerators what they are) and where truth depends on elegance and completeness.

Steven Weinberg (Austin, Texas) has no qualms about his theoretical devotions, now to the theory of superstrings. The theory, Weinberg said, is the product of a post-Bohr dialectic between quantum field theory on the one hand and scattering-matrix theory on the other. Weinberg decided last January "to drop everything" for the theory of superstrings, which avoids in a natural way the mathematical difficulties of other approaches to the unification of the forces of nature and "which has that flavour of uniqueness that we look for". Unashamed, he said that there is not yet the slightest evidence for this elegant theory.

**Philip Campbell**

US–China nuclear pact

# Foes in Congress speak out

*Washington*

PRESIDENT Reagan's nuclear technology transfer agreement with China ran into more problems last week, with the admission by the Nuclear Regulatory Commission (NRC) that the nature of China's assurances on the implementation of nuclear policies "could lead to future misunderstandings". NRC is required by its Nuclear Anti-Proliferation Act (1978) to comment on proposed agreements. NRC would have preferred the agreement to contain a "clear statement of US consent rights for the subsequent reprocessing of enrichment of US-supplied nuclear fuel", it revealed in a letter to Senator William Proxmire (Democrat, Wisconsin), one of the main critics of the agreement. NRC last week would not discuss its concern in detail or comment on allegations that China has helped Pakistan to build nuclear weapons. But NRC provided testimony to Congress in a closed session last week.

Congress is examining the issues raised by the cooperation pact and has until the end of next month to act if it wants to try to alter any of its provisions. Testifying before the Senate Foreign Relations Committee last week, Professor John Cooper of Rhodes College, Tennessee, described the "periodic and extreme" shifts in China's foreign policy during the past 35 years and said that China's record on export policy is "not good".

Paul Leventhal, president of the Nuclear Control Institute, told the committee that the agreement is "seriously flawed" in its "legitimizing" of plutonium, neglect of safeguards and potential for disputes. Senator John Glenn (Democrat, Ohio) has just introduced legislation embodying some of these worries. His bill seeks to tighten safeguards and demands documentation of China's non-proliferation policy, conditions that would make the agreement "salvageable", he says.

Edward Luck, president of the US United Nations Association, told the committee that trying to force China to make further assurances would be "counterproductive" given the efforts already made to meet US concern about non-proliferation. Energy Secretary John Herrington and ambassador Richard Kennedy, negotiator of the agreement, told the committee that both countries would gain "significant benefits" on ratification of the agreement.

It is difficult to predict whether Congress will try to alter parts of the agreement, the first of its kind between the United States and a single nuclear weapons state. The opposition to the pact is thought to be a "significant minority", unlikely to put President Reagan in the embarrassing position of having to renegotiate with China.

**Maxine Clarke**