known to be among the oldest materials in the solar system. About half the samples were from the Allende meteorite. While looking at inclusions—pockets of material isolated within another material—within the meteorites, the scientists found that the ratios of the oxygen 18 isotope to more common oxygen 16 and of oxygen 17 to oxygen 16 were much lower than they had expected. In fact, report Robert N. Clayton, Lawrence Grossman and Toshiko K. Mayeda in the Nov. 2 SCIENCE, both ratios were "lower . . . than all other meteorites studied, and the ratios extend well below the range observed for terrestrial rocks."

This might have been due to some kind of radiation or particle bombardment destroying the less stable heavy isotopes, except that the two ratios are lower by the same amount—"a highly unlikely coincidence," they point out, for a process beginning with different isotopes. The alternative is that some material containing an extra amount of pure oxygen 16 was present when the inclusions were formed.

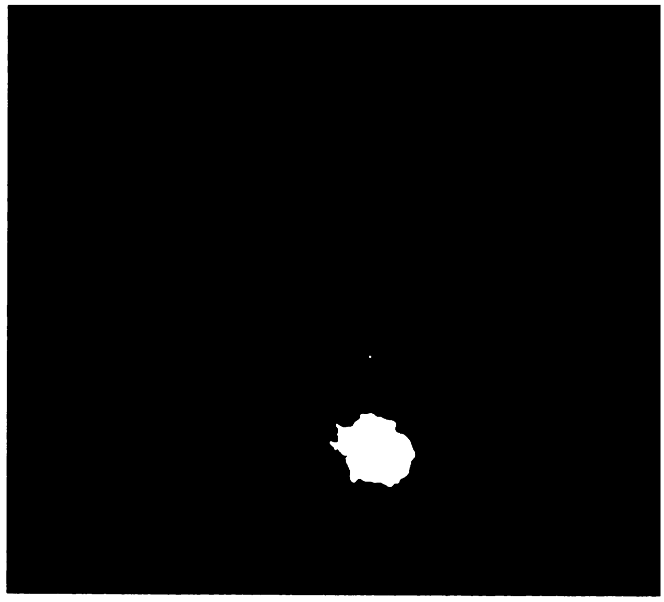
But where did it come from? Only the sun could have produced oxygen 16 in suitable quantities, says Clayton, and there are many elements missing from the inclusions which ought to be there if even a part of their substance was cast off by the sun. Furthermore, he says, the meteorites formed out among the planets, and there is no presently known process by which the sun could have thrown the oxygen 16 out so far in such quantities—the solar wind is too weak.

The exciting possibility that remains, the scientists suggest, is that this mystery material—primordial grains made all or in part of oxygen 16—came from somewhere outside the solar system.

If this is true, it almost certainly happened before the solar system formed some 4.6 billion years ago. Otherwise the extra oxygen 16 could hardly have found its way into the meteorite inclusions. This may in turn reveal a surprising fact about the solar system's formation: namely that it was not very hot, astronomically speaking, even in its earliest days. Great heat would have vaporized the oxygen-16-rich grains so that they simply vanished into the homogenety of the primordial cloud.

There is hope, the authors believe, that additional research can settle the mystery of the substance's origin. After all, Clayton told SCIENCE NEWS, a solar origin is not impossible, just unlikely. There is a reasonable chance, he points out, that if the inclusions in C2 and C3 meteorites did indeed form differently from the earth, moon and ordinary chondrites, there may be additional clues in the abundances of isotopes of other light elements. □

Comet Kohoutek



This is the photo that revealed the tail of the major comet now approaching the sun, although the tail is pointing almost directly away from earth. It was taken by Elizabeth Roemer on Sept. 29, 1973, using the 61-inch telescope at the University of Arizona. The comet is getting steadily brighter, and it may start becoming visible to the naked eye (on the southeast horizon before morning twilight) about Nov. 22.

Elizabeth Roemer

Are quarks and partons mini-black-holes?

Black holes are usually thought of as large objects having the mass of (or having been made from) a fairly sizable star. However, for the last two years one of the experts' experts in the subject, Stephen Hawking of Cambridge University, has been pleading the cause of mini-black-holes, gravitationally collapsed objects with masses as low as 1/100,000 of a gram. Hawking supposes that 99.9 percent of the mass of the universe is mini-black-holes, and thus solves an old cosmological problem, the closure of the universe. We do not see enough massive objects to close the universe—to decelerate, by gravitational force, the present expansion of the universe, stop it and reverse it to a collapse. But unseen mini-black-holes could add enough mass for closure.

Now, Jack Sarfatt of the International Center for Theoretical Physics in Trieste uses Hawking's mini-black-holes to solve a number of problems in astrophysics and particle physics and to provide the world with the threat of an unusual form of ecological catastrophe. As the NEW SCIENTIST puts it: "His hypothesis . . . has that all-embracing quality that raises the hackles of any self-respecting skeptic." It is, nevertheless, interesting.

Sarfatt begins with the showers of elementary particles that appear in the atmosphere as a result of the arrival of the most energetic cosmic rays. There are many more such showers than can plausibly be explained by the usual theoretical mechanism: interaction of a high-energy proton with an atomic nucleus in the upper atmosphere. Sarfatt supposes that the excess comes from interactions of mini-black-holes, weighing 1/100,000 of a gram and 10^{-33} centimeters in size, with electrically charged particles of dust in the atmosphere. What comes out of this collision is a virtual photon and a graviton, the still hypothetical particle that carries the effect of gravitational forces from place to place. The graviton's energy would be 10^{20} electron-volts. This graviton would decay into the particles that make up a cosmic-ray shower.

Sarfatt then goes on to postulate that the quarks or partons that both theory and experiment seem to indicate make up the sructure of protons are nothing less than mini-black-holes. They would be bound together by their very great gravitational attraction for each other. A proton would consist of a central core of bound mini-black-holes orbited by a ring of black holes "reminiscent of Saturn."

Astrophysically and cosmologically Sarfatt contends that gravitational fusion of mini-black-holes could have supplied the energy for the big bang at the start of the universe. It can also explain the energy yield of quasars, the lack of the expected flux of solar neutrinos and the production of giant solar flares. Anomalous quasar redshifts, formation of galaxies and even the heating of the earth can also be explained by mini-black-holes.

Finally there is the ecological effect. It relates to the cosmic-ray air showers. If we keep on polluting our atmosphere with dust particles there may come to be more and more air showers. The resulting rise in the atmospheric flux of ionizing radiation could be detrimental to human health and genetics.