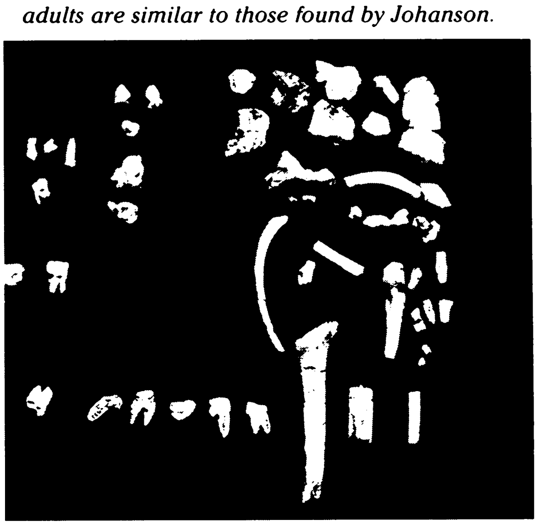
Path followed by man's direct ancestors.

contention that the brain was too small to master [moderately developed] tools."

At least for now, however, Leakey stops short of naming the creatures who left those ancient tracks. "They were direct ancestors to man," she says. But, she adds it is "doubtful" they represented pure *Homo,* although they displayed "a lot of human characteristics." On the other hand, the individual was "not like other *Australopithecus* ... which died out." Johanson and White "have made *Australopithecus afarensis* ancestral to *Australopithecus africanus* [The South African ape], which doesn't seem to be possible," says Leakey.

"We'll leave it [the naming of the species] open until we have more material," she says. "It's a very knotty problem." □

adults are similar to those found by Johanson.



The hole in the middle of the Milky Way

In the summer of 1978 evidence was reported that indicates the existence of an extremely massive object in the center of the galaxy M87. It is suspected that this may be a gigantic black hole, millions of times as massive as the sun. M87 is a very active galaxy. It is the scene of highly energetic processes that manifest themselves in a copious output of radiation of all kinds. Accepting the proposition that there is a black hole in M87 — and most astronomers are probably reserving judgment at the moment — one must ask whether such massive black holes are characteristic of active galaxies particularly or of all galaxies including quiescent ones like our own.

In a report soon to be published in the Astrophysical Journal Luis F. Rodriguez and Eric J. Chaisson of the Harvard Smithsonian Center for Astrophysics present evidence that there may be a massive black hole in the center of our galaxy. The evidence on M87 came from studies of the optical brightness of the center and of the collective motion of stars near the center. Rodriguez and Chaisson derive their evidence from a study of the radio brightness and motion of the ionized gas at the center, the radio source Sagittarius A West, done with the Haystack radio telescope in Westford, Mass.

The results indicate that the source has a core-and-halo structure. Studies of the line broadening — that is, of the Doppler shifts in the emission of certain resonant frequencies by the gas that result from motion of the gas — indicate that the gas is going around in orbit. The dynamics of Sagittarius A West, say Rodriguez and Chaisson, can be attributed to Keplerian (that is, quasi-planetary) rotation induced by the gravitational field of the stellar population to be expected at the galactic center plus an extremely compact mass equal to five million times the sun's mass. Whether this is a black hole remains to be observed. □

Fusion: Light-ion excitement

Implosion fusion is the name given to experiments that aim to produce nuclear fusion by crushing a pellet of the appropriate fuel, deuterium or deuterium and tritium. The implosion is caused by suddenly delivering energy to the surface of the pellet. The energy causes an explosive ablation of the surface layer, and the back reaction from the ablation implodes the core of the pellet.

To deliver the triggering energy physicists first thought of light, concentrated, coherent, powerful beams of laser light. Laser fusion is being pursued rather heavily in the United States and in a number of other countries. Concentrated high-energy beams of other things can also do the job: electrons, light ions, even heavy ions. Electron beams have been experimented with to a somewhat lesser extent than laser beams, but the ions were generally considered a long shot. The difficulty of making beams of ions, accelerating them and delivering them to the target made them seem less attractive.

Now, as a result of experimental developments of the last two years, there is intense interest in the use of ion beams as energy deliverers in implosion fusion. At the recent 1979 Particle Accelerator Conference in San Francisco physicists and accelerator technologists crowded a ballroom of the Palace Hotel to hear Gerold Yonas of the Sandia Corp. in Albuquerque tell the reasons why. They are two: First and foremost, it has proven easier to make and energize beams of light ions than people expected. That is not as trivial as it sounds. In this field, experiment and technology have little detailed theory to go by, and testing reasonable expectations is a laborious process. Second, if the ion beams can be made and brought to the target, they deliver energy much more easily than light or electrons.

And if it weren't for a rather fortunate circumstance, ion beam production might not be easier. Ion beams are made in diodes. These are much larger than the diodes in an old fashioned radio, and their electrodes are shaped and arranged for this purpose rather than for those of the radio. When you apply an accelerating voltage between the electrodes of the diode, what you are likely to get, says Yonas, is electrons. They are light and come off the cathode easily. Even if the electric field is made strong enough to pull atomic nuclei, that is, ions, out, there will still be a lot of electrons in the way.

The solution is to apply a pulsed magnetic field across the gap. This makes the electrons go into orbit, and the cathode is effectively surrounded by an ionized gas source with an orbiting cloud of electrons. The combination of forces provided by all this makes it convenient for the ions to come out, in currents up to millions of amperes.

The experimenters at Sandia have been working this out in an apparatus called PROTO II. The great excitement is grounded in their belief that the method will scale up. Since 1977 they have been building an apparatus called EBFA I. The building was completed late last year, and now the equipment to go into it is arriving. In a few years they expect to have 36 separate modules working together to produce 30 terawatts of power.

Once the ion beam arrives at the fusion target, it has advantages over the other

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means of energy delivery. For best results the energy must be delivered to the shallowest possible layer of the surface of the pellet in the quickest possible time. Light has the problems of penetrating the pellet and of being reflected by it. Much effort is going into the proper sizing and shaping of pellets to minimize these effects and to concentrate the light. Light also has a preheating effect on the pellet surface that lessens the desired explosive effect of the ablation when it comes. Electrons also penetrate, and there is an effort to coat pellets with substances that will absorb electrons efficiently. Ions tend to give up their energy in the outermost atomic layers of the pellet, and there is no preheat problem.

The major outstanding problem, Yonas points out, is getting the ion beam from the diode to the target. It will be necessary to transport it at least several centimeters. A beam of this kind cannot be run through a vacuum tube like the beams of the usual particle accelerators. The beam is too dense with particles of the same electric charge. Their collective repulsive effect on each other, called the space charge effect, will destroy the coherence of the beam. In some cases, according to one commentator, it can even stop and reverse the motion of the beam.

The solution to the problem seems to be to run the ion beams, and the electron beams, which are under experimentation in the same places, through a background gas. The background gas could be electrically neutral or it could be ionized. Its purpose is to dilute the space charge effect. But it is also an obstacle, which is why it is removed in ordinary accelerators, in which space charge is not so serious a problem. The ion or electron beam must be guided through the background gas by a magnetic pathway, which can be formed by external magnets or by electrically dissociating the background gas. Experiments on these problems are underway at Sandia and at the Naval Research Laboratory and elsewhere in the world, especially the Soviet Union. Yonas was questioned about the Angara machine, now being built in Leningrad, which is more or less the Soviet counterpart of EBFA. According to his present information, Angara is expected to be operating at the megajoule energy level by 1985. At Sandia they are now beginning the design work to raise EBFA from its present 30 kilojoule design to the megajoule level.

Work of this kind can also have applications to so-called particle-beam weapons. A part of the excitement and of the interest in Soviet work may stem from that.

The work on the production of light ion beams that has so far been done has concentrated on protons, which are the lightest possible ions. But where protons operate, nuclei of other light elements can usually be made to follow, and ultimately, perhaps with some difficulty, even fairly heavy ions may be made to go the route. □

Rockfest 10: Comparing and competing

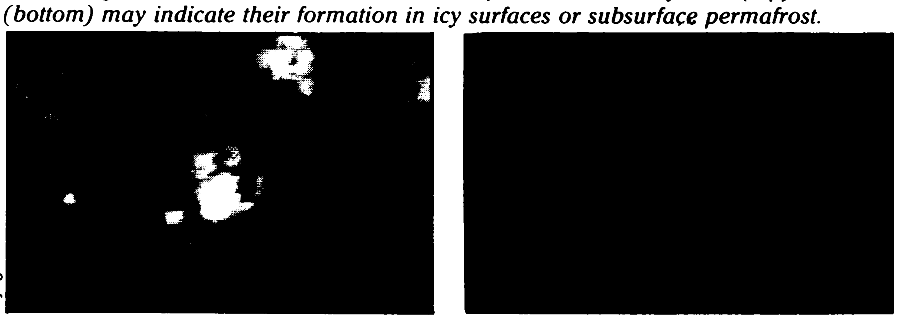
When the first Lunar Science Conference was held at NASA's Manned Spacecraft Center (now Johnson Space Center) in Houston in January of 1970, the more than 800 scientists attending it were focused on a single subject: the first study results on the Apollo 11 moonrocks, brought to earth just six months before. This year's gathering, held last week at JSC, was the tenth such affair, but the subject matter has expanded to include at least that many solar system objects — the moon, the planets from Mercury through Jupiter and Jupiter's four Galilean satellites, as well as meteorites, tektites, asteroids, comets and space dust. Last year the event was renamed the Lunar *and Planetary* Science Conference, and this year's nearly 700 participants showed why.

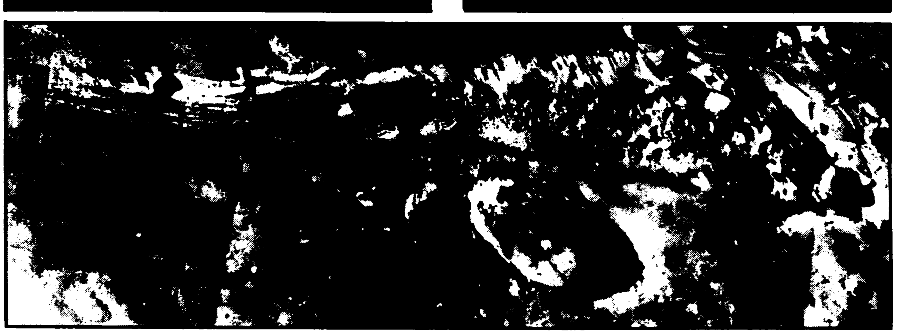
So many new results were described from planetary missions such as Voyager, Pioneer Venus and Viking that some researchers felt that the moon was in danger of being lost in the shuffle. Indeed, a proposed Lunar Polar Orbiter satellite, designed to make global lunar studies to expand the limited Apollo and Soviet Luna data, has been on a far back burner at NASA, in large part because of competing proposals for Venus, Mars and comets. Even the existing moonrocks, most of which have not yet been touched, had their study funds cut last year from \$5.7 million to a single million (pending a new division of the effort between NASA and the National Science Foundation), although the space agency hopes to reallocate enough money to get the amount back up to about \$3.7 million. The cut is particularly ironic in view of discoveries still being made, such as last week's announcement of a new low-potassium, high-rare-earth basalt type found in the decade-old Apollo 11 samples. "The politics of pure science," says moon-veteran astronaut John Young, "is one of the toughest politics there is."

Through it all, David R. Criswell of the Lunar and Planetary Institute managed to sound confident as he introduced a somewhat blue-sky session on proposed ideas for future lunar exploration. "I'm personally convinced," he told his audience, "that we will return to the moon. Six years, maybe the next century, but we *will* return." In the session, topics ranged from an Exxon engineer's evaluation of drilling tens of kilometers into the lunar crust, to a description by Jack B. Hartung of the State University of New York at Stony Brook of a huge mat of "light-pipes" that could reveal meteorite impacts to a distant monitor by flashes of light, to a talk by Alan Binder of the New University at Kiel, Germany, about an envisioned unmanned lunar program involving 16 landing craft in a seismic and heat-flow network plus 18 robot vehicles to bring back new samples.

There are certainly regions from which scientists wish they had such samples — a young crater floor (bearing signs of the moon's later evolution), the lunar farside (which may retain more of its original surface), the polar regions (which have been suggested by some researchers to serve as a "cold sink" for a still-present reservoir of frozen water). In learning about the formation of the solar system's planets, according to the University of Maryland's C. G. Andre, "the moon may no longer be the most fashionable body in the sky, but it is our greatest hope." So saying, she proceeded to cite orbital X-ray data indicating the apparent presence of early, magnesium-rich basalts in all five of the lunar basins for which the data exist — yet they

Competing with the moon for attention: Central-pit craters on Ganymede (top) and Mars (bottom) may indicate their formation in icy surfaces or subsurface permafrost.


Voyager 1/NASA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