solid-ice flow from filling them in, and too low in mass for gravity to cause them to slump. Study may show this as a characteristic difference between the Saturnian moons and larger bodies, but a similarity with smaller objects such as the Martian satellite Phobos, which is dominated by a deep crater called Stickney.

Out from Mimas is Enceladus, of special interest because a 2:1 orbital resonance with Dione may cause it to be subjected to the same tidal stresses linked with the volcanism on Jupiter's moon Io and the cracked but otherwise smooth surface of Europa. Though Voyager 1 got no closer than 200,000 km (Voyager 2 will do far better), the limited-resolution photos suggest to Soderblom that Enceladus (diameter 500±20 km) may be Saturn's least-cratered moon — right next to heavily bombed Mimas.

Next is Tethys (1,050±20 km), also to be better seen by Voyager 2, revealing a 750-kilometer-long trench on one side and a 180-km circular feature — probably an impact crater — on the other. Some researchers suggest that the trench may be a crack formed by the blow. Shoemaker goes considerably further, maintaining that many craters on Saturn's moons look more irregular than do those on rocky worlds, as if they resulted from impacts into surfaces that were already heavily shattered. On such low-gravity objects, he notes, such crustal irregularities could well be the dominant factor in the appearance of subsequently formed craters.

Of the entire Saturnian family, Dione (1,120±20 km) looks the most like earth's moon. Smooth areas separate many of its numerous craters, similar to the intercrater plains caused by lava flows on other bodies — but Dione is mostly ice. Dione's density, Soderblom observes, could mean that it contains enough heat-producing radioactive elements for the crust to have remained capable of resurfacing itself until after its early meteorite-bombardment episodes were over. Sinuous "valleys" may indicate cracks in the crust, while light-colored "wispy" features on the surface have been tentatively interpreted as "leaks" of volatile material from within.

Rhea (1,530±20 km) bears more scars than it has room for, with craters upon craters, large and small. Strangely, Soderblom notes, part of the surface seems to lack the large craters that are part of the mix everywhere else — a seemingly innocuous difference, but with what Soderblom sees as potentially far-reaching consequences. The general opinion has been that the cratered bodies in the solar system received most of their meteorite impacts during a single span of years called the "great bombardment" early in the system's history. So why, the scientists ask, should one part of Rhea, just as pitted as the rest in terms of numbers, show a different range of crater sizes than the one usually thought to characterize the great bombardment? One possibility, he suggests, is that more than one bombing took place, with the latter "bombs" representing a population of objects with a different size range — comet nuclei, perhaps, or debris orbiting the early proto-Saturn.

Continued on page 332

Photos: JPL

Thin stripe on Saturn's 11th moon was seen to have moved in images taken 13 minutes apart, revealing it to be the edge-shadow of a previously unknown ring — the G-ring.

Interferon: The explosion continues

The promise of interferon has yet to be fulfilled, but much promising research on the putative anticancer and antiviral agent has been reported since Charles Weissmann of the University of Zurich and of Biogen announced production of interferon with recombinant DNA techniques (SN: 1/26/80, p. 52). An update on interferon was presented last week in Washington at the first annual Congress on Interferon Research, and the news was encouraging.

David Goeddel of Genentech in San Francisco, for instance, reported that interferon has now been produced via recombinant DNA techniques not only by Biogen but by three other genetic engineering companies as well — Genentech, Genex of Rockville, Md. and Cetus of Berkeley, Calif. Whereas only several molecules of interferon per *E. coli* cell could be made in January, 20,000 to 30,000 molecules can now be produced. What's more, not only interferon from leukocytes (white blood cells) but interferon from fibroblasts (connective tissue cells) can now be made with recombinant DNA. In fact, as Weissmann predicts, interferon supplies made with recombinant DNA may become available for clinical trials as soon as a year and a half from now.

Other new ways of making larger and more economical batches of interferon also look promising. For instance, Flow Laboratories in McLean, Va., is now growing fibroblast cells on beads of sugar called dextran instead of in petri dishes in order to make fibroblast interferon for National Cancer Institute clinical trials. Pharmacia Fine Chemicals in Uppsala, Sweden, is also producing fibroblast interferon this way. The reason is that the dextran beads increase the surface for fibroblast cell growth over that of petri dishes and hence increase the cells' production of interferon. The technique offers a way to make substantial amounts of fibroblast interferon for clinical trials *now*, M.C. Hirtenstein of Pharmacia explains, although the recombinant DNA production of interferon will probably eventually outstrip the dextran bead method.

Meanwhile, investigators are using the limited interferon now available to conduct clinical trials of interferon's potential as an anticancer drug. Preliminary results from these studies suggest that interferon can counter some human cancers, but will not be a cancer panacea. For instance, J.U. Gutterman of the M.D. Anderson Hospital in Houston and colleagues have given interferon to 29 patients with advanced colon, prostate and ovarian cancers, which are extremely resistant to drugs. Three of the patients experienced partial remissions, eight some improvement and 18 had no response. J. Treuner of Tübingen University in Tübingen, West Germany, and his co-workers have given interferon to six neuroblastoma patients. One had a total remission, two partial remissions. Ernest C. Borden of the University of Wisconsin at Madison reports that he and his team have found interferon can make recurrent breast cancer regress, but only in some patients. "There is nothing in the data now that suggests that interferon is a cancer cure," Borden concludes. However, there has been a lot of progress in treating various cancers during the past 15 years, he says, and he foresees "interferon adding something to the other treatment advances."

Although interferon has long given evidence of fighting viruses, such evidence is now being bolstered with new results. During the past five years, for instance, Thomas C. Merigan of Stanford University College of Medicine and his co-workers have treated 32 chronic hepatitis patients with interferon plus an antiviral drug because they had not been able to totally eradicate the condition with either one of them alone. They then followed the patients for a mean of 10 months and found that some patients showed a fall in the hepatitis virus antigen and felt better. One patient was cured. Others, however, were not helped.

New insights into interferon per se are also emerging. For instance, there is growing evidence for not only two major kinds of interferon—leukocyte and fibroblast—but for a third one, gamma. And now subforms of leukocyte and fibroblast interferons are also taking a bow. Weissmann reports there are at least 10 different species of leukocyte interferon. Pravinkumar Sehgal of Rockefeller University in New York City and colleagues have found two different types of fibroblast interferon, and one appears to be a more potent antiviral agent than the other.

More is also being learned about how interferon works as an antiviral or anticancer agent. For instance, B.Y. Rubin and S.L. Gupta of the Sloan-Kettering Cancer Center in New York City tested leukocyte, fibroblast and gamma interferons on various viruses. They report that the three major forms of interferon tended to inhibit the growth of specific viruses, indicating that the viruses differ in their sensitivity to different interferons, or that the interferons' antiviral actions may be different.

Many questions remain, but interferon research has come a long way in a short time. □

Plasma physicists have a lot to say

"Is plasma physics about fusion?" As he opened a morning of papers on astrophysical plasmas at the meeting in San Diego last week of the American Physical Society Division of Plasma Physics, Charles Kennel related that he had recently been asked that question. His reply—"Not entirely" — was appropriate for the morning's topic. Astrophysics contains many instances where plasmas — ionized gases —in which nuclear fusions neither happen nor are intended to happen, play an important role. They can even make a galaxy ripple like a flag in the wind. This is the analogy used by G. Bertin of Massachusetts Institute of Technology, L. Blitz and G. Lake of the University of California at Berkeley, J. W-K. Mark of Lawrence Livermore National Laboratory and R. Sinha of the National Radio Astronomy Observatory at Socorro, N.M., in presenting a theory to explain how unstable warps in the flat plane of a galaxy can form as a result of differences in rotation rate between the slow moving central part (bulge and halo) and the slower outer part.

Nevertheless, the paper presented by Eugene N. Parker of the University of Chicago, whom Kennel was introducing, dwelt mainly on the physics of the sun, in which nuclear fusion is of central importance. This conjunction underlines also the Promethean quality of the science: If it succeeds, it will be to bring the energy source of the stars to earth to put it at the disposal of humanity. Plasma physics aims at a pure scientific understanding of the behavior of ionized gases, but even in developing that it will serve the practical task, which characterizes it in the eyes of the public and the world's legislators and which is the ground of enthusiasm for many of its practitioners.

The practical task of developing controlled thermonuclear fusion has an even higher profile in the appearance of the science of plasma physics, because plasma physics has been a more empirical science than many. Theory has never had a good time in plasma physics. This is in contrast to the situation in, say, particle physics. In particle physics the theorists dominate, and they have already precisely predicted the outcomes of generations of experiments yet to be mounted. In plasma physics an experiment can still yield real surprises for all concerned.

These considerations mean that nobody is certain what will work. So a large variety of approaches are tried. Designs and concepts are mixed. Old approaches that have been dropped are picked up again, often with new twists determined by changed circumstances.

"Why build stellarators," asked P. Grieger of the Institute for Plasma Physics in Garching, West Germany. The idea of the stellarator is now 30 or 40 years old. It was the first approach to the confinement of a plasma in a magnetic field shaped like a torus or doughnut. (A plasma is electrically charged, and so it will fly apart if not contained by a counter force.) A plasma must also be heated to induce fusions. In this department stellarators were found wanting—at least relatively—and enthusiasm went to the later invented tokamak.

The tokamak has what is called ohmic heating: An electric current is induced to flow through the plasma itself, and the plasma heats up through its own electrical resistance. Ohmic heating works, but not as well as the inventors of the tokamak believed it would. Auxiliary heating methods have had to be devised for tokamaks. One of these is the injection of beams of neutral gas into the plasma. The neutral gas adds to the density of the plasma (also a desirable thing) and by the friction of collision heats it.

Neutral beam injection brings us back to Grieger and the series of stellarator experiments done at Garching in recent years under the name Wendelstein. (The name means "stone of transmutation" or philosophers' stone.) It turns out that the neutral beams will also heat the stellarators and the stellarators seem much more promising with better heating and their lack of the problems with magnetic field shapes that ohmic heating bequeathes to tokamaks. The audience seemed impressed by what they heard.

Another old idea that never worked very well is the magnetic mirror. The basic idea is to make a cylindrical magnetic field and to try to close it down at the ends so that the ends reflect the particles back toward the middle. In practice it proved impossible to close the ends very efficiently. Now the tandem mirror at Lawrence Livermore National Laboratory, the TMX as it is called, is showing how to do it. The ends are closed by other mirrors so that there are three in line. The end mirrors are what is called "baseball mirrors." They depend on the peculiarly twisted magnetic fields produced by coils shaped like the seams of a baseball. This field holds a dense plasma, which, being electrically charged, sets up an electrostatic field that helps confine the plasma in the central mirror. A year ago the Livermore group announced that they had evidence that plasma was being confined in the central portion of the TMX as though the end plugs were working. As one of them, Paul Drake, related to the meeting, they have examined and tested their evidence and are now convinced that the TMX does in fact have electrostatic plugging and not some other kind that might have happened unintentionally and that the plugging is as theory predicts.

Another way of confining plasma is the nonmagnetic or inertial means. A fuel pellet is crushed by being hit from all sides by beams of laser-like or energetic particles. Fusions take place during the implosion, releasing a small puff of energy.

Implosion fusion experiments began with laser light. Lasers are easily available and light is easy to transport from laser to target. But light does not deliver energy to the target very efficiently. Energetic particles—electrons, protons—would deliver energy better. Heavy ions — say ionized uranium — would be optimum. But there are difficulties in the production of such ions and in accelerating them to the energies necessary to induce a fusion implosion. Because of these and other problems, physicists weren't sure the task was practical, but now they think they can do it. The history of the subject has progressed from light to electrons to light ions and now to enthusiasm with heavy ions. A statement characterizing the progress went something like this: "We didn't think it would work but we tried it and it worked." It seems that plasma physicists are able to say that more than they used to. □