Science & Technology

Voyager data offer new concept of how Saturn was formed

by Dr. John Schoonover, Director of Physics Research, Fusion Energy Foundation

The data returned to astrophysicists from the Voyager 1 spacecraft as it flew by the planet Saturn revealed all the computational weaknesses of conventional "Newtonian" physics and, if it need be shown, also revealed the fundamental ontological fallacies in the conventional Newtonian model of the universe. On the other hand, Saturn's ring system encouraged some astrophysicists that their theoretical work on the planets is heading in the right direction.

For about five years, Drs. James B. Pollock and Allan S. Grossman, both of Ames Research Center, Dr. Ronald Moore of Iowa State University, and Dr. Harold C. Graboske of Lawrence Livermore Laboratory have been developing a theoretical model for application to both Jupiter and Saturn. The model treats the planets as if they were low-mass stars. On this hypothesis, they have been able to determine the broad features of the two planets' evolution over the approximately 4.5 billion-year history of the solar system.

Their research has provided tentative answers to a number of significant questions. Why does Saturn have a ring system? What is the material composing Saturn's rings? How did it get where it is? Why does Saturn's moon Titan have a nitrogen, methane, and ammonia atmosphere? Why do both Jupiter and Saturn radiate more energy than they receive from the sun?

The Saturnian system is a complex interplay of physical phenomena that in many ways mirror the complexity of the whole solar system. By sorting out some of the important evolutionary questions concerning the origin and development of significant features of that system, it may be possible to gain further insight into the history of our solar system as a whole.

Saturn's evolution

Saturn started out some billions of years ago, according to Pollock's model, as a tenuous gas cloud some hundreds of times the current size of the planet. Just as in the case of the Sun, which formed from much larger clouds, in which the Saturn cloud was included, the major components were the elements hydrogen and helium. As a result of the formation of a gravitational instability, whose origin is yet to be explained, this cloud began to condense. As it became more and more dense, tremendous heat built up at its center, finally causing molecules of hydrogen to break down into separate atoms. At this point the cloud became hydrodynamically unstable, and over an extremely short period of time, only about one year, the entire cloud collapsed to about its present size.

During that collapse, much of the heat that had already been generated, as well as new heat from this collapse, was trapped inside the planet. Since then it has been seeping out and radiating away, cooling the planet over billions of years.

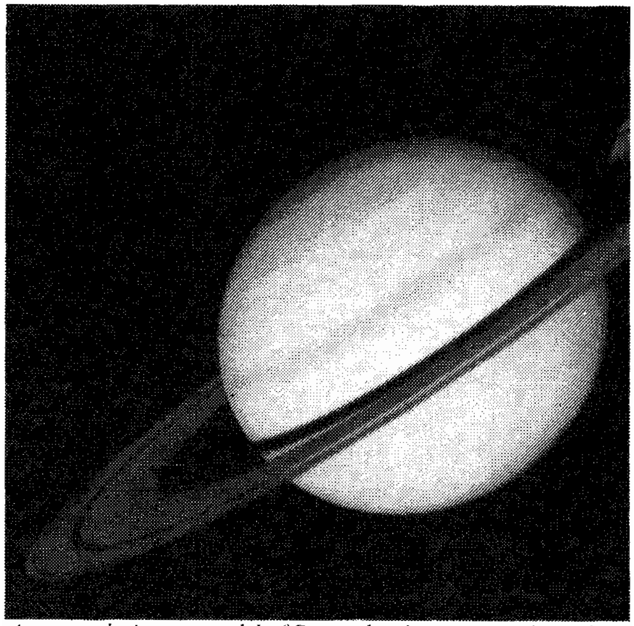
Following this scenario in detail, Pollock and his coworkers have found that they can account quite accurately for the heat generated by Jupiter. On the other hand, they find that Saturn is radiating more heat than they expected from the model. They hope, however, to account for this discrepancy as terrestrial experiments more accurately determine the properties of hydrogen and helium under the pressure and temperature conditions that exist in the interior of Saturn.

These data are being developed independently of research on planetary formation due to their importance for inertial confinement fusion and the production of hydrogen bombs.

As the Saturnian gas cloud condensed into the planet, the large amount of heat radiated, many times the current amount, would prevent volatile materials such as water vapor, ammonia, and methane present in the cloud from condensing. This material would form a disc at Saturn's equator rotating with the planet. Pollock and his coworkers have determined on the basis of the temperatures they would expect to find at different distances from the planet, that water vapor could condense into ice in the region now occupied by the rings and the inner moons.

However, it would have been too hot for ammonia and methane to condense closer than comparable to the orbit of the moon of Titan. These results were qualitatively supported by the evidence that the ring material is largely formed of water ice and that Titan's atmosphere is rich in nitrogen, with some methane as well. The nitrogen results from the chemical decomposition by sunlight of the ammonia that would originally have dominated the atmosphere.

Further confirmation of this model is that the satellites outside the region of the rings have progressively increasing densities, indicating a smaller and smaller component of ice in their make up, with more and more dense materials.


NASA

A new evolutionary model of Saturn has begun to explain why its rings exist.

Structure of ring system

One question that immediately comes to mind is, if Saturn and Jupiter underwent similar evolution, why doesn't Jupiter have a ring system?

The answer to this is not too difficult in light of the low-mass star model. It has been known for a long time that if a moon were to come too close to its planet, it would be torn apart by tidal forces similar to those that generate the tides in the earth's seas. Conversely, within that region close to the planet bounded by the Roche limit, no large moon could form. Now, Jupiter, being much larger than Saturn, generated much more heat during its early evolution. As a result, the material from which a ring system could form could not condense into a ring inside the Roche limit. Outside that limit, it could form into moons. In the Saturn case, the rings are inside the Roche limit, where moons could not form.

There are still many questions to be answered. Why, for example, is there such a differentiated substructure in Saturn's rings? This kind of structure poses severe challenges to the simplistic, and wrong, particle-by-particle interaction dynamics that most scientists are trained to take as primary. The approach embedded in the Pollock model, a continuum mechanics based largely on hydrodynamics, is closer to an appropriate model for this kind of problem.

Hydrodynamics versus particle dynamics

The difficulty with the particle dynamics, introduced by Isaac Newton in the 17th century, is that when there are more than two particles interacting, the dynamical problem becomes, in principle, insoluble. In recent years, mathematical physicists have shown that the system of three Newtonian particles is capable of taking on arbitrary forms of motion. Since this is clearly not what occurs in the real universe, the Newtonian approach to mechanics must be fundamentally flawed.

The types of motions that are becoming more and more recognized as dominant in the real world largely fall under the category of collective, self-organizing motions. These kinds of phenomena can be accessed by a theory that takes evolutionary processes that shape the nature of lawful behavior as primary.

To further clarify the distinction expressed above, take the problem of explaining the existence of planets. According to the Newtonian particle approach, planets are formed by the fortuitous aggregation of one bit of randomly moving matter after another into a larger and larger ball.

Unfortunately, no one has yet developed a plausible mechanism, so this bit of silliness stands as the best theory available. It would probably be a fruitful line of research to consider the formation of subsidiary hydrodynamic singularities in the extensive gas cloud that was the pre-stellar sun, by the actions generated during its own condensation into a star. If it could be shown that these singularities could be the sites of gravitational instabilities such as the one that led to the formation of Saturn in Pollock's model, then we might be able to explain the current spacing and composition of the planets in a rational way.

The Saturn system provides a microcosm for the same sort of process on a solar system-wide scale. This is the case since, so far there is no mechanism that accounts for the existence or the spacing of Saturn's moons.