Space physics

Does Uranus have a magnetic field?

from A.J. Dessler

IN JUST a matter of days, Voyager 2, now nearly 8.4 years into its grand tour of the Solar System, will sweep past Uranus. The prospect has inspired discussion of the strength of the planet's magnetic field, published estimates of which at cloudtop level range from tens of gauss down to zero. This fascinating state of confusion is the result of recent data from Voyager which do not confirm past observations of Uranus from Earth orbit.

In 1982, John Clarke, using the Earth-orbiting International Ultraviolet Explorer (IUE), reported that Uranus is a bright scource of ultraviolet light[1]. Clarke's interpretation of these observations, which was immediately and widely accepted, was that the ultraviolet emission from Uranus is radiating from a bright aurora, which would be caused by the bombardment of the upper atmosphere by energetic electrons or ions. It is these and subsequent IUE observations, plus the specific hypothesis of an aurora on Uranus, that led to the estimates of a strong planetary field. To extract power either from the solar wind or from the rotation of the planet so as to drive an aurora that can produce the observed 10^{11} watts of ultraviolet emission, the planetary magnetic field has to create a magnetosphere large enough to engage the power source. Because of our experience with aurora on Earth, Jupiter and Saturn, quantitative models are at hand. Application of these models to Uranus results in a most probable value of the magnetic field at cloudtop level of 4–13 gauss, with 0.6 gauss as the minimum value[2].

Until a few months ago, Uranus was, in a sense, an astrophysical object. It can be seen well enough from Earth (and from Earth orbit) to learn a few facts and to develop some nice stories. Because there are few facts, simple ideas tend to fit them and they become a consensus rather quickly. Uncertainty and debate have been rare. But we are now witnessing a transition of Uranus from an astrophysical object to a space-physics object; facts provided by Voyager are about to overwhelm the theories. The impending encounter has made the theoretical community both humble and open-minded.

The problem is that if the IUE-detected ultraviolet light is indeed from an aurora created inside an enormous magnetosphere, then our experience with Earth, Jupiter and Saturn would lead us to expect Uranus to be a significant source of radio noise. Consequently, it was predicted that Voyager's first detection of magnetospheric radio emission would occur early last year and no later than August[2,3]. The failure of Voyager to pick up any radio signals from Uranus so far suggests that the ultraviolet emission is not generated by an aurora and that a strong (or even a weak) planetary magnetic field may not exist. Alternative explanations for the ultraviolet emission are therefore being put forward.

Shemansky, in the January issue of *Geophysical Research Letters*, and Ip, in next week's *Nature*, agree that the mysterious mechanism that produces bright ultraviolet glow from the sunlit hemispheres of Jupiter and Saturn also operates at Uranus. This glow is not auroral in nature — it occurs at lower and mid-latitudes, stops suddenly in the absence of sunlight and is clearly a separate phenomenon from the standard high-altitude aurora. Shemansky further suggests that Uranus has a negligible planetary magnetic field, while Ip argues that the strength of the magnetic field is immaterial, but it could be quite weak.

The lack of the expected radio emission has inspired yet another argument for a weak magnetic field. Curtis and Mess[4] note that the blackness of the rings and satellites of Uranus could be explained if there were no magnetosphere to shield them from the solar wind. Particle bombardment by the solar wind would remove surface ices, leaving dark, possibly carbonaceous, materials on the surface. They propose a cloudtop magnetic field of no more than 4×10^{-5} gauss.

Another proposal for a weak field will be put forward by Axford and Vasyliunas in next week's *Nature*. They argue that the magnetic field of Uranus originates in an

Jacques Oudin 1908–1985

WITH the death of Jacques Oudin on 15 October 1985, the international community of immunologists has lost one of its uncontested pioneers. From 1937, after completing his medical studies, Oudin spent his entire scientific career at the Pasteur Institute in Paris. From 1959 onwards he headed the laboratory of Immunochimie Analytique which was especially created for him. In 1979, the year after his retirement, a symposium at the Pasteur celebrated his exceptional career, highlighted by three major discoveries.

Some time after joining the Pasteur, while working in the laboratory of Chimie Microbienne, Jacques Oudin attempted to devise a one-step method to count the diverse antigen–antibody systems involved in the reaction of an appropriate antiserum and a complex mixture of antigens. He came up with the remarkable idea of using a gelled medium for the antigen–antibody precipitation reaction designing, in 1946, the method of immunochemical analysis. For a long time thereafter this was the only method for the enumeration and identification of antigens as well as the quantification of antigens and antibodies. Oudin formulated the quantitative laws and the general rules of the method, one of them — for which he had so often to fight — being that an antigen molecule gives only one precipitation zone with the corresponding antibodies.

It was while using antigen–antibody precipitates as immunizing material to elicit production of antibodies unispecific to the antigen present in the complex, that Jacques Oudin observed the first manifestation of what he defined in 1956 as allotypy of proteins, namely their property of exhibiting variations of antigenic specificities among individuals of an animal species. Before the multichain structure of immunoglobulins was known, he showed the presence on the same rabbit immunoglobulin molecule of allotypic specificities governed by genes at two different and independent loci, which he had just identified. The discovery of allotypy opened the fertile field of immunogenetics and the fascinating area of immune-system manipulations.

Working along the same lines, Oudin found in 1963 that rabbit antibodies possessed additional antigenic specificities which seemed unique to antibodies to a given antigen in one individual or a group of individuals. He proposed the term idiotypy to designate them. This observation (made independently in 1963 for human antibodies by Kunkel, Mannik and Williams at the Rockfeller Institute) led to experiments which were crucial to our appreciation of both the potential repertoire of antibody diversity and the regulation of its expression. It also provided the basic material for Jerne's theory of the network of antibody variable-domain interactions and of the dynamic equilibrium of the immune system.

It is worth pointing out how far and wide the words coined by Oudin have spread: isotypy and isotype, allotypy and allotype, and particularly idiotypy and idiotype. But it would be presumptuous to try to capture with mere words the rigour of Jacques Oudin's scientific thinking, the peculiarity of his solitary creativeness, his talent in identifying important facts in unexpected findings that would have disconcerted less discerning minds, his intransigent empiricism, his perfectionism and the extreme care he took over all his writing. We have been priviledged to benefit from such an exemplary mind.

Guy Bordenave