CONFERENCE SUMMARY

R. A. Treumann*

It is a nice custom to end a meeting with a short summary of the highlights which have been presented in the various sessions, and it is a pleasure for myself to have been given by the organizers the opportunity to collect the most interesting results of this conference.

As usual one cannot do justice to everybody in a short summary like this. This would imply a brief repetition of all the talks. I rather restrict myself to the most spectacular results which have been communicated to us. Naturally, these results are of a more observational than theoretical nature, which is no surprise. We have a number of very successful new spacecraft flying, Ulysses, Galileo, Wind, Polar. A number of other spacecraft will be operating in orbit when these proceedings will appear, not all of them of course armed with instrumentation capable to detect radio emission from other planets or even the Earth. In addition groundbased observations remain important and have recently been proven to be highly capable of detecting fine structures in radio emissions which may indicate some still unknown mechanisms of radio wave generation. These methods are limited to the observation of radio waves from the Earth's environment and from the Sun. The detection and close experimental investigation of radio emissions from the smaller and greater planets is however restricted to spacecraft measurements.

Spacecraft in the past have provided invaluable information about the plasma environment of the Earth and the planets. That this is still the case has recently been demonstrated by the spectacular measurements of Ulysses and Wind in the solar wind. These measurements improve our knowledge about the properties of the solar wind which is extremely important for an account of the propagation properties of emissions in various regions of space and for the dynamics of the magnetospheres which are the sources of the planetary radio emissions.

But let us come back to the highlights of this conference. As the most spectacular information we witnessed here in this auditorium I consider the detection of the tiny magnetosphere of Jupiter's small satellite Ganymede. The discovery of this magnetosphere was the central point of Don Gurnett's exciting talk. We all could feel and share the great enthusiasm which Don was occupied with when he presented the overwhelmingly convincing arguments he and his team had read from the wave recordings during the Galileo flyby at Ganymede. That such a small moon can have an own magnetosphere is not only exciting but also surprising in itself. But I for my part, and I am sure that I share this feeling together with Don and the other members of his team, am most excited by the fact that it were the plasma wave observations from which the magnetosphere of

*Max-Planck-Institute for Extraterrestrial Physics, 85740 Garching/Munich, FRG

Ganymede was inferred. Too often the plasma waves are considered a stepchild in the space community. But as in other cases detection of the plasma/upper hybrid frequency or the trapped radiation cut-offs give very precise determinations of the local or remote plasma density, the plasma content, and sometimes from direction findings also about the magnetic field structure and source position of radiation. The high state-of-the-art of plasma wave measurement and analysis as is represented by Don Gurnett and his team made it possible to find that Ganymede, the small Jupiter moon which looks so unimportant, possessed an entire own magnetosphere with all the dynamics a magnetosphere shows. This magnetosphere is embedded into Jupiter's magnetosphere. A large number of questions and problems will arise from this discovery. How is the interaction between the two magnetospheres? What kind of plasma exchange takes place between the two? How does reconnection work in this case? Has Ganymede its own aurora or not? Does it emit its own radio waves like Jupiter, Saturn, the Earth? There are many more problems all of them crying for more missions to be sent to Jupiter, crying for theories. The magnetosphere of Ganymede tells us something about the interior of the moon and about its differences to the other moons. Moreover, this discovery cries for a mission to Mercury, the small planet close to the Sun of whom we know that he possesses a magnetosphere, in order to investigate this magnetosphere, its wave structure and possible radiation from it. The consequences of the discovery of Ganymede's magnetosphere will be very broad. Don Gurnett, in his abstract which he submitted to this meeting before the Ganymede flyby wrote: "... data are to be recorded during the first flyby of Ganymede, which will occur on June 27, 1996. Although no data have been received at the time of this writing, if the data are successfully recovered, a report will be given on the initial observations." Certainly, at the time of the writing Don did not expect that this report would become so exciting and successful as it was.

Certainly, Ganymede's magnetosphere was the most spectacular event of this meeting. But there have been a number of other excellent radio and wave observations which have been reported on by Bill Kurth, Mike Kaiser and Mike Reiner, all related to Jupiter and Io observations and Earth's emissions. Kurth presented Galileo observations while Kaiser and Reiner presented Wind observations. What impressed me was the extraordinary quality of all these data.

But in this short review I would like to point on another interesting discovery which I feel is of importance in understanding the dynamics of magnetospheres using wave and in particular radio wave emissions. The discovery which I have in mind is the detection of low frequency drifting radio emissions from the Earth's geomagnetic tail which Roger Anderson presented and gave the name of terrestrial type III bursts. The paper from Desch who used Wind observations is closely related to this discovery. Moreover, as Roger pointed out, Jack Steinberg, also on Wind, is as well involved. But Roger used the instrumentation of Geotail, the Japanese spacecraft which performed highly successful measurements in situ in the Earth's tail.

Terrestrial type III bursts because of their similarity to solar and interplanetary type III bursts are not only an indication of the changing plasma frequency in the plasma sheet of the Earth's tail but also for the acceleration of small groups in the tail during substorm onset probably by reconnection. Further investigation of this effect and emission is therefore of very high importance. We know already from AMPTE IRM measurements that the outermost lobeward magnetic field line in the plasma sheet may guide bursts of electron beams from the tail into the auroral zone. The detection was there local by observing the excitation of upper hybrid waves. Now when type III bursts are available, one has a clue to infer about the injection site and the source of the electrons similar to the Sun.

I will not review all the other very interesting measurements which have been presented during this meeting. I will only briefly point your attention to the ground-based observations of magnetospheric radio emission which Jim LaBelle has spoken about. These emissions are faint, sporadic and highly time variable as could also be seen from his huge poster which he showed. The incredible amount of fine structure in these emissions is really surprising and has not been expected. The question is, how is such a fine structure generated, how is the emission generated at first, and how is it possible that it is detected at the ground below the dense ionosphere. Jim has argued that it might somehow leak through the ionosphere in ionospheric holes. This is extremely interesting. But the emission mechanism is not well known, and the fine structure puts a mystery in front of any theorist.

By this I come to the theory. The theory of the emission we had initially put forward was a maser emission. A better account of this kind of theory has been given at this meeting by Al Weatherwax (a paper presented by Jim LaBelle as well). Jim has also argued that wave–wave interaction at the bi-resonance would give similar emissions. Both kinds of mechanisms are interesting. But a theory of the fine structure is awaited and may solve the problem.

But let me do justice to some other theoretical developments about which we heard in this meeting. The first is the excellent investigation of thermal fluctuations in a magnetized plasma presented by Nicole Meyer-Vernet and Michel Moncuquet. This theory gives information about temperatures and densities from electron cyclotron thermal emissions in Jupiter's Io plasma torus. The theory is very beautiful and has been developed up to a stage where it can be used for plasma investigation.

Last I pick out the paper by Philippe Louarn. He investigated the maser emission and polarization properties of the radiation emitted in a narrow source. This is an important theoretical paper insofar as it clearly shows that both types of waves can be emitted: X-modes and O-modes with the X-mode much more intense but narrow in frequency and the O-mode coming from a much broader region and though being faint occupying a larger time and space sector. I feel that this paper has made important progress in the theory and understanding of maser emission in the Earth's magnetosphere but has much wider application to planetary emissions during planetary aurorae and substorms in other magnetospheres.

I conclude this short account of the highlights of this meeting which I selected from my personal point of view and which thus reflect just my particular taste, with the remark that we had a number of very important and interesting proposals for improvements of observational techniques, data analysis, and for further observations for example from a Moon-borne observatory. I apologize to all of those whose papers I have not mentioned (including my own).

Finally, it is mandatory to me to thank in the names of all of you the organizers for organizing this wonderful meeting as for their hospitality which we all could experience. Let us look forward to the 5th International Workshop on Radio Emissions from Planetary Magnetospheres. I am sure that it will be as exciting as the present one was and bring our field of research up ahead another important step towards understanding planetary radio emission and its use in sounding planetary magnetospheres.