REPORT OF MEETING 1

This was a truly educational and productive workshop. Because of the relative small number of participants (several team members had to cancel on short notice, so that only six attended meeting 1), free questions and discussions could be entertained by the presenters. We managed to fulfill the three goals enumerated in the abstract above, and more than ever, we are of the opinion that a positive detection of radio emissions will be accomplished soon. Below is the summary of meeting 1.

1. Discussion of the Underlying Physics

Non-thermal radio emissions from Jupiter in the kHz to GHz frequency range have been observed from earth and spacecraft for over forty years. At frequencies lower than 40 MHz, the emission is dominated by cyclotron emission. At higher frequencies, synchrotron emission from energetic electrons trapped in Jupiter's magnetic field dominates the emission process. The intrinsic power radiated in the decametric regime is several hundred Giga-Watt, and this power is supplied by some combination of the average solar wind and impulsive solar events such as coronal mass ejections.

As for the actual physical process of planetary radio emissions, it is now understood that they are generated by a maser-like instability from keV electron distributions precipitating in the auroral regions of magnetized planets. The emissions produced consist of burst from a few seconds to over an hour in duration, at frequencies close to the local electron cyclotron frequency. The generation mechanism is so effective that brightness temperatures of $\approx 10^{15}$ to 10^{20} K are archived, yielding a Jupiter/Sun contrast of ≈ 1. However, early studies that scaled the Jupiter emissions to an arbitrary distance of 10 parsecs distance[1] concluded that the flux density levels at Earth would be very low, too low to allow detection.

More recently, about 100 planets outside the solar system have been discovered (e.g., http://www.extrasolar.com/planetsearch.html) with (optical) radial velocity measurements, and their orbital elements determined. Different from the Jupiter – Sun geometry, many of the planets are very close to their primary (< 0.1 AU in many cases), and thus they find themselves in a much stronger stellar wind than Jupiter. The energy input into a magnetosphere so close to a star is orders of magnitude larger than that experienced by Jupiter. Many are more massive than Jupiter, so their magnetic field strengths are likely larger.

Recent theoretical studies[2] have proposed scaling "laws" to estimate the flux density expected from solar (stellar) wind driven cyclotron emissions:

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[1] Gary, B., and S. Gulkis, Jet Propulsion Laboratory Internal Memorandum, December 16, 1974.

[2] Desh. M. D., and M. L. Kaiser, Nature, 310, 755, 1984; Farell, W. M., et al., Geophys. Res. Lett., (in press), 2003; Zarka, P., R. A. Treumann, B. P. Ryabov, and V. B. Ryabov, Astrophys. and Space Science, 277, 293, 2001.

$$P_r \propto \left(\frac{m}{m_j}\right)^{1.33} \left(\frac{d}{d_j}\right)^{-1.60} 400 \times 10^9 \text{ W} \qquad (1)$$

Thus the intrinsic power emitted in the radio spectrum from such a planet is expected to be much stronger than for Jupiter.

2. Targets

The targets of observation were selected based on the expected flux level using variations of Blackett's "law"(an expression relating the planet's magnetic field to its mass), yielding a minimum flux (flux1), and a maximum flux (flux2). Also considered and desired were high galactic latitude to decrease background noise, close distance to decrease sensitivities to some model assumptions, and the expected range for the electron cyclotron frequency (f_{ce}). The latter was used to select for f_{ce} > than 150 MHz.

The following targets where selected:

Priority	name	M (Jup)	a (AU)	dist (pc)	Flux1 (mJy)	Flux2 (mJy)	Gal Lat
1	tauboo	5.2	0.05	15.6	717.8	4446.8	-73.9
2	gj876b	2.4	0.21	4.7	43.6	123.6	59.6
2	gj876c	0.7	0.13	4.7	102.3	85.9	59.6
3	hd179949	1.2	0.04	27.0	211.1	310.3	15.8
4	70vir	9.3	0.48	18.1	1.6	17.9	-74.1
5	Upsandb	0.9	0.06	13.5	147.3	170.8	20.7

In addition to gj876, upsand is also a multi-planet system consisting of three known planets, possibly increasing the probability of detection.

3. Choice of Radio Telescope

A large aperture is required for the detection of the radio signals. At this time two radio telescopes appear to be the best candidates: The Giant Meter Telescope (GMRT) in India, and the Ukrainian T-shape Radio Telescope (UTR-2). Due to atmospheric considerations, observations are best performed in winter. The team is invited to perform observations then.

There is a call out for proposals for GMRT, with a submission deadline of April 7, 2004, The call is for observations starting in summer 2004. A proposal has been submitted to GMRT for a week of observations of the targets in the list above.

GMRT is located at a site about 80 km north of Pune. GMRT consists of 30 fully steerable gigantic parabolic dishes of 45m diameter each spread over distances of up to 25 km. Fourteen of the thirty dishes are located more or less randomly in a compact central array in a region of about 1 sq km. The remaining sixteen dishes are spread out along the three arms of an approximately `Y'-shaped configuration over a much larger region, with the longest interferometric baseline of about 25 km.

Since the cyclotron emission occurs in short bursts, we plan to observe the target sources in the pulsar mode, where the data can be recorded at integration time shorter than a second. To optimize the sensitivity in this mode, we would like to use the phased array mode. We also plan to record simultaneous interferometric data in the normal interferometric mode using all antennas. This will help us both in identifying Radio Frequency Interference (RFI) as well as to make maps of the region of the sky to find out any possible radio counterpart. At 150 MHz, we hope to get at least one MHz RFI free band, at this bandwidth, one hour integration using central square antennas will give us a sensitivity of about 4 mJy, where as the expected flux densities for most of the target sources are a few hundred mJy (see above table). At 235 MHz, for similar observations, a sensitivity of about one mJy can be achieved.