Advanced Jupiter Science Summary

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Presentation to the Green Bank Radio Jove Meeting
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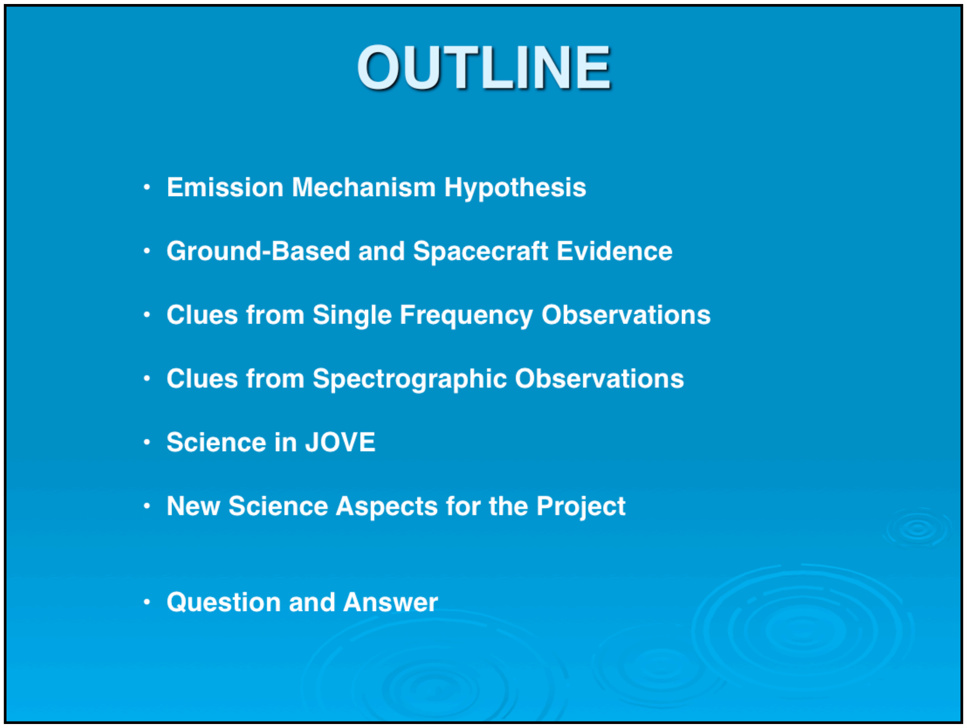
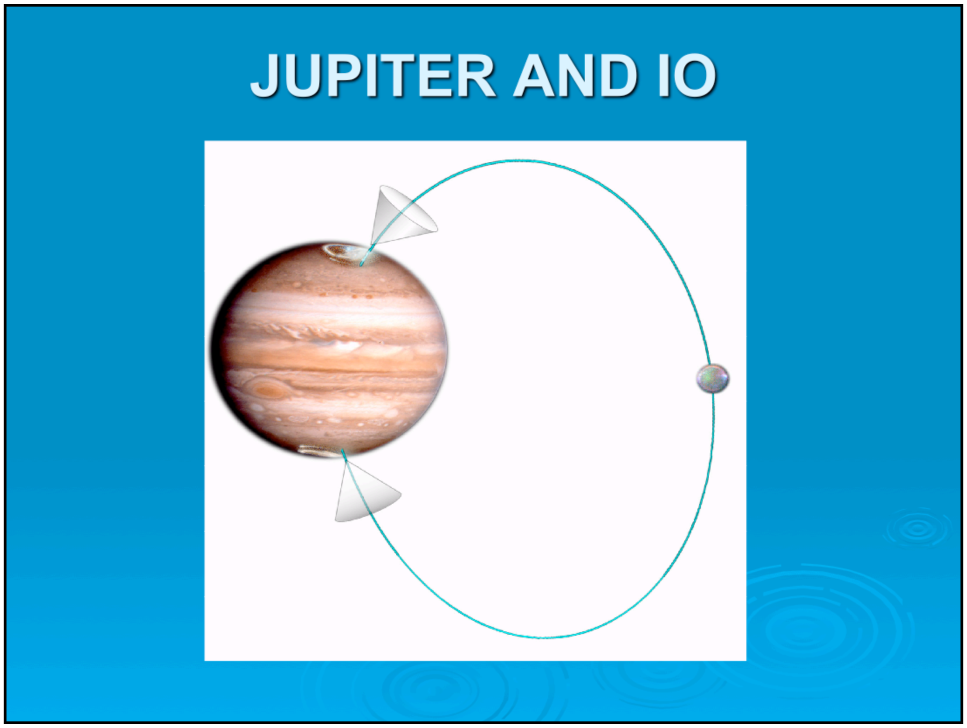
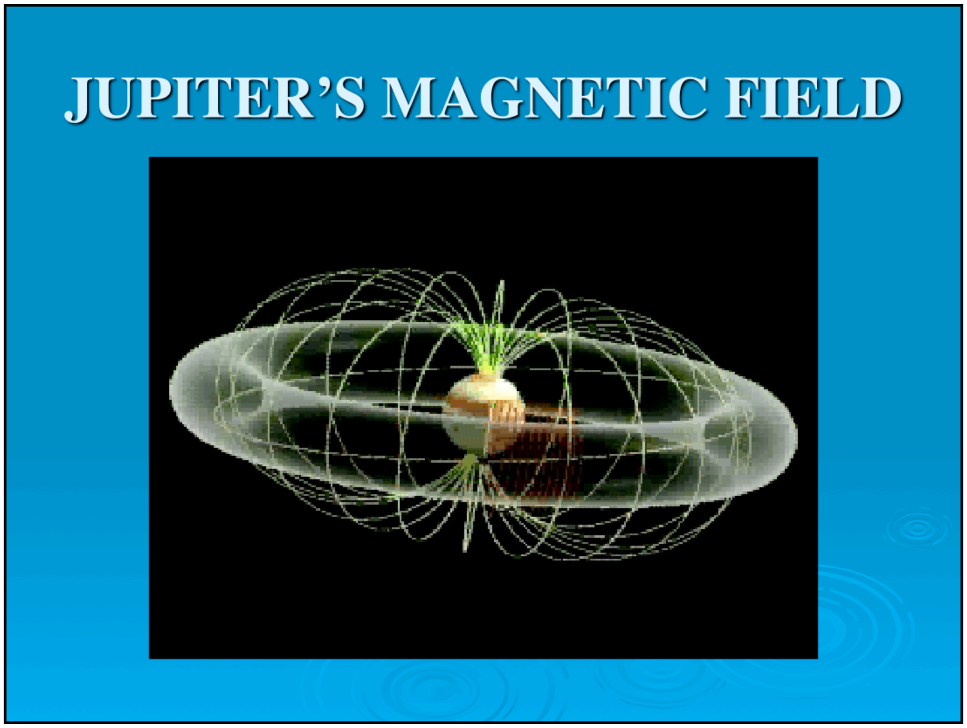


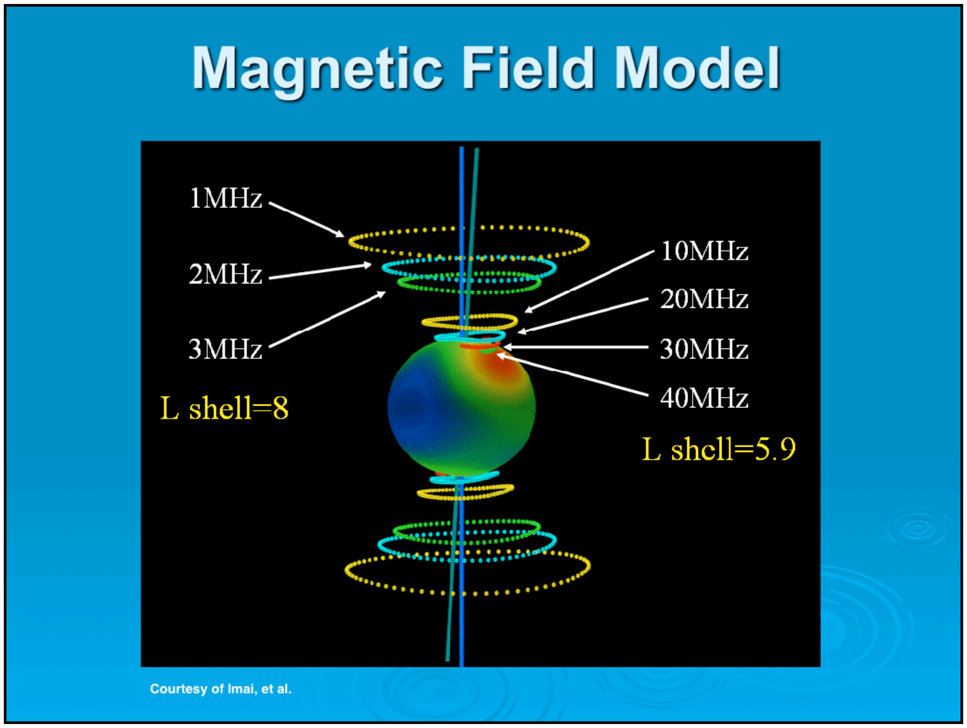
As we heard in earlier presentations, we believe that cyclotron maser emission or similar types of mechanisms cause the Jovian radio emission to be emitted by charged particles spiraling along Jupiter magnetic field lines as defined by Jupiter magnetic field models. . The resulting conical emission can be used to explain why we receive Jupiter emission at certain predictable times and not at others. If we consider the different conical emission structures that are generated at different frequencies and how those frequencies are modified by the magnetic field models we can explain some of the characteristics seen in Jovian spectrographic observations. We hope to use the archived observations done by Radio Jove observers in conjunction with new explorations of the emissions which will take place with instruments such as the Long Wavelength Array and the Juno mission to uncover new discoveries about Jupiter and its multitude of mysteries.



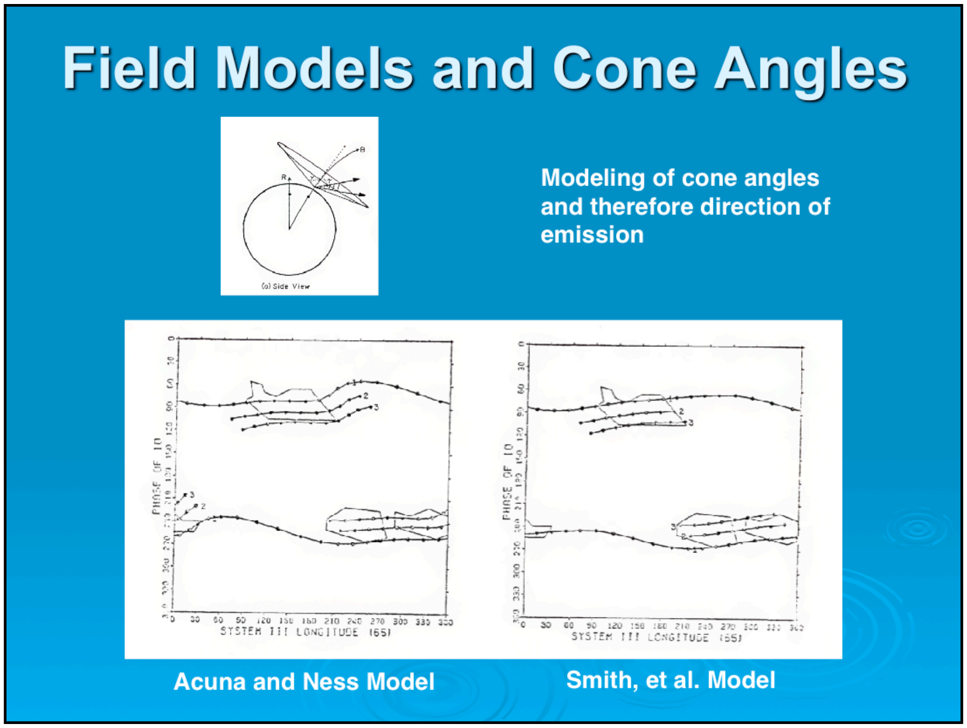
Various theories of Jovian radio emission invoke the properties of the cyclotron maser emission mechanism in which charged particles from the region of Io spiral down the magnetic field lines that connect Io to Jupiter and emit a hollow conical beam of radiation with the cone axis centered on the magnetic field line. This can happen in both the northern and southern hemispheres of Jupiter. The field lines that go through Io would be particularly active with charged particle flow.



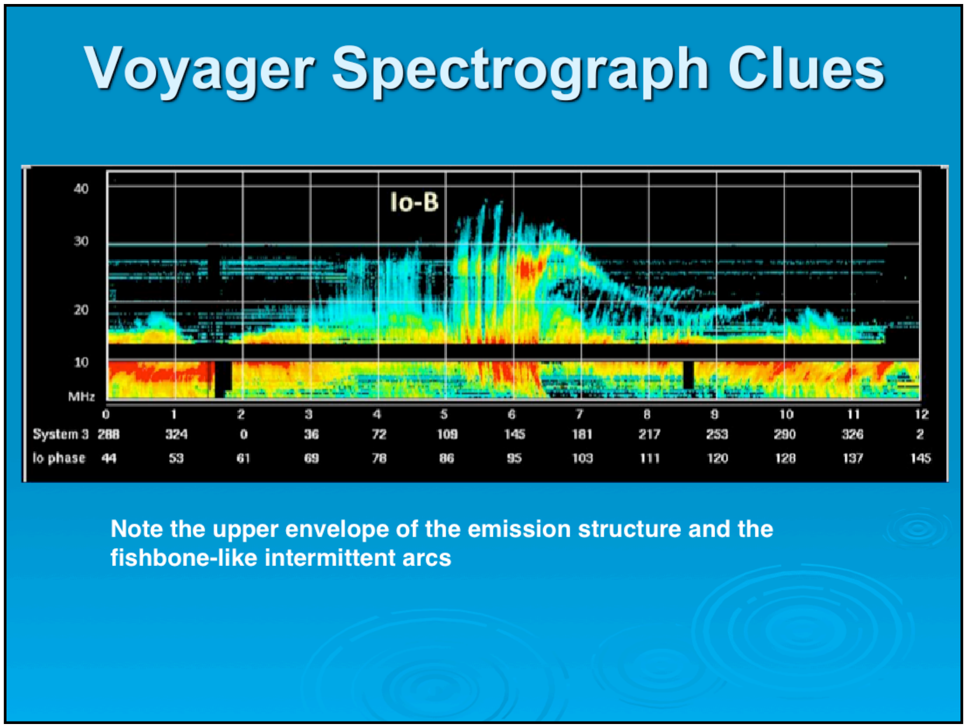
In the image of Jupiter we see the green lines representing magnetic field lines similar to the type of field lines one would see if there were a large bar magnet embedded in Jupiter tilted at 10˚ to the rotational axis. Note also the gray donut-shaped region around Jupiter. This represents the cloud of gas and plasma that can be found around the orbit of Io, one of the large moons of Jupiter. A typical bar magnet generates a magnetic field that we call dipolar, which is one of the simplest magnetic fields. Jupiter's magnetic field however is more complex than a simple dipolar magnetic field. It is as though there were other smaller bar magnets also distributed inside Jupiter in such a way that they modify the field that is closer in to Jupiter creating significant quadrupolar, octupolar, and higher order modifications to the field, especially in the region close to Jupiter.



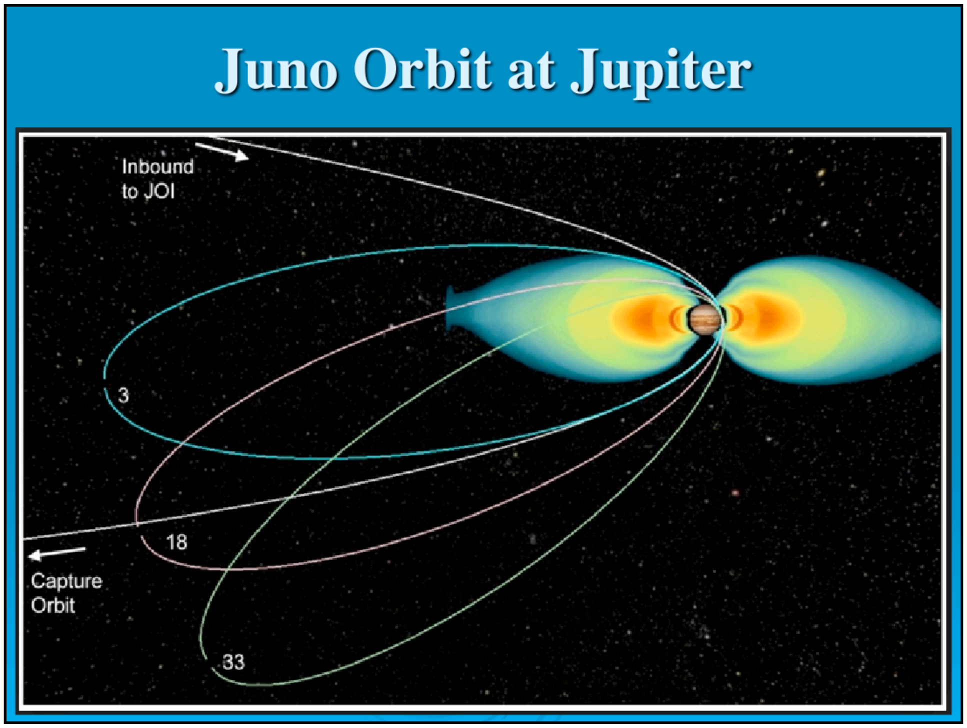
As charged particles spiral down the magnetic field lines toward Jupiter's cloud tops the frequency of the radio emission they send out depends on the magnetic field strength at the location where they are emitting. As they get closer to Jupiter the magnetic field strength increases and they emit at higher and higher frequencies. This image shows the calculated positions of various frequencies of radiation for regular intervals of field lines around Jupiter. These were calculated using a magnetic field model that was derived from spacecraft measurements of the Jovian magnetic field. Note that at the cloud tops of Jupiter the false colors on the Jovian sphere indicate the magnetic field magnitude from the highest value represented by the red color to lower values represented by other colors in a rainbow like progression through the colors. In a dipolar magnetic field one would expect the strongest magnetic field at the Jupiter surface to be located near the north or south magnetic poles represented by the green line going through Jupiter. The measured magnetic field model shows significant departures from a simple dipolar field with a highest field value at the cloud tops being significantly away from the pole. Particles traveling along field lines going into the clouds at this maximum field location would generate emission at a frequency of about 40 MHz. Note that Jovian decametric radio emission has not been observed at a frequency above roughly 40 MHz. The magnetic field model was derived from spacecraft measurements made at quite a distance from Jupiter and it is expected that spacecraft that get closer to Jupiter, such as Juno, will find a much more complex magnetic field.



If one assumes particles emitting in a hollow conical pattern with a cone angle of gamma as shown in the tip image (a view of Jupiter with the North pole at the top and the magnetic field line B going down to the surface you can calculate the Central Meridian Longitude and Io phase that are necessary in order for the radio emission to be directed at Earth. The CML and Io Phase can be plotted on the CML-Io Phase diagrams as indicated in the bottom image which were generated using slightly different magnetic field models as calculated by Acuna and Ness and by Smith, et al. In each case the eimission from one side of the cone comes from the high probability region we call source B and the other side corresponds to the high probability regions we call Sources A and C. These were calculated for emission at 20 MHz. If we assume only a partially filled cone the emission will disappear when the filled part of the cone no longer points at Earth. These cutoffs roughly correspond to the boundaries of the high probability regions.. Thus, the model explains some interesting aspects of the source morphology.



This spectrogram taken by the Voyager Planetary Radio Astronomy Instrument when Voyager was close to Jupiter shows very intriguing structure from the Source B radio emission region. Note that the highest frequency of the emission is near 40 MHz and this occurs near the maximum magnetic field at Jupiter's cloud tops which would support radio emission in the 40 MHz range. Note the upper cutoff frequencies in other parts of the spectrogram presumably coming from field lines having lower maximum frequencies of emission. Using the current best magnetic field models the maximum frequency observed in various parts of the spectrogram does not match well with the the anticipated values based on the calculations from the field model. Perhaps it would be better if we had a more accurate magnetic field model for the region close to the cloud tops. For this we need magnetic field measurements closer to the Jovian gaseous surface. Note also the "arc" structure giving the spectrogram a fishbone type of appearance. These arcs have also been modeled using assumptions of cone like emission structures. A number of assumptions have to be made for a good fit to these arcs. Perhaps a better fit is possible with fewer assumptions if there were a better magnetic field model for the region close to Jupiter.



The Juno mission to Jupiter is designed to have orbits of Jupiter with periJove very close to the planet after the Jupiter Orbit Insertion (JOI) engine burn. This will allow study of the intense radiation environment close to the planet, but will also result in a much improved magnetic field model. The radio emissions observed by Juno in these strange orbits should be very interesting and will benefit by having simultaneous observations from Earth.