Reports

Decametric Radio Pulses from Jupiter: Characteristics

Abstract. *On occasion the decametric radio bursts from Jupiter contain pulses of millisecond duration. Study of data for 2 years shows that the distribution in Jovian longitude of these fast pulses is different from that of the more common pulses of longer duration. The two classes of pulses also appear to be differently affected by the position of the innermost Galilean satellite.*

The well-known decametric radio outbursts from Jupiter are received as bursts of pulses. For analytical purposes we have assigned to three distinct types of pulses character numbers 1, 2, and 3. Type 1, which is rare, consists of smooth pulses lasting tens of seconds. Most of the Jovian emission consists of pulses of type 2, which last from tenths of a second to several seconds. Type-3 pulses have durations in the millisecond range; because of the distinctive sound produced by a train of these pulses, they have been described, somewhat inelegantly, as "spitting." The real origin of the pulse structure is open to question, for simultaneous recordings made at widely separated stations often fail to show detailed correlation (*1*); an ionospheric origin has been suggested, and Douglas and Smith (*2*) recently presented evidence that the pulses may be formed by interplanetary modulation of the Jovian emission, which according to this hypothesis would be quasi-continuous.

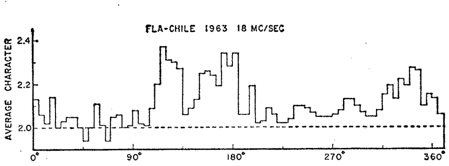

Fig. 1. Average pulse character, as a function of System-III central-meridian longitude, for 18-Mc/sec radiation from Jupiter during the 1963 apparition.

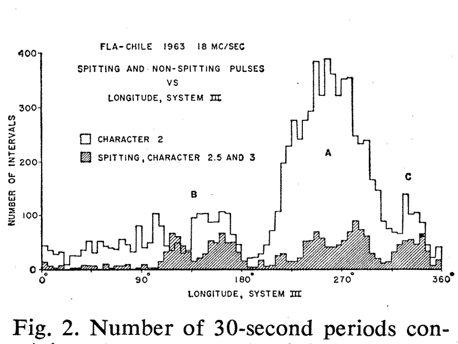

Fig. 2. Number of 30-second periods containing character-2 and spitting pulses, as a function of System-III longitude, for the 18-Mc/sec emission during the 1963 apparition. The shaded area represents spitting, while the unshaded area represents type-2 pulses. *A*, *B*, and *C* identify the usual decametric "sources."

Recently we reported briefly on a preliminary study that suggested that the pulse character correlates with the Jovian longitude that happens to be facing Earth at the time of emission (*3*); the study was based on a limited quantity of 18-Mc/sec data obtained at the Gainesville station of the University of Florida Radio Observatory during the apparition of 1962. Because of its important implications, this investigation has now been extended to the complete apparitions of 1963 and 1964, including the 18-Mc/sec data from not only the Gainesville station but also the observatory's southern-hemisphere field station near Maipu, Chile.

With the help of the high-speed (5-mm/sec) pen recordings, a character number was assigned to each 30-second period of Jovian emission. Periods containing pulses of mixed types were given half-integral character numbers; if, for example, a period contained pulses of types 2 and 3, it was assigned a character number of 2.5. Figure 1 shows the average character number as a function of System-III Jovian longitude. For convenience in analysis the planet was divided, as usual, into 5° zones of longitude. In determining the average character for a given 5°-longitude zone, a computer program summed the number of 30-second periods of emission that fell within that zone, weighting each by its own character number; this sum was then divided by the total number of periods. It should be remembered that a character number higher than 2.0 means that some "spitting" radiation occurred for that zone; thus the figure suggests that the millisecond bursts tended to cluster in the longitude region between 110° and 200°, or in the general vicinity of decametric "source" *B*—the same conclusion that was reached in the preliminary study of the 1962 data (*3*). There is an indication of further clustering near source *C* (310° to 360°).

It is perhaps even more instructive to analyze the pulses in the manner shown in Figs. 2 and 3; here the computer was used to total the number of 30-second periods of each character (1, 1.5, 2, 2.5, 3.0) that occurred while each 5° longitude zone was on the central meridian. In Figs. 2 and 3, types 2.5 and 3 have been combined to produce the shaded regions of "spitting" radiation, while the unshaded histograms represent emission of type 2 only. No correlation was attempted for types 1 and 1.5, since they constituted less than 1 percent of the 18-Mc/sec data in both 1963 and 1964.

The striking feature of these diagrams is that, while the spitting radiation is concentrated in the familiar "sources" *A*, *B*, and *C*, it seems to occur with roughly equal probability from all three. On the other hand type-2 emission is heavily concentrated in source *A*; in 1963, for example, 74 percent of the type-2 activity arose from this source. This result, of course, explains the form of Fig. 1: spitting pulses represent about one-third of the

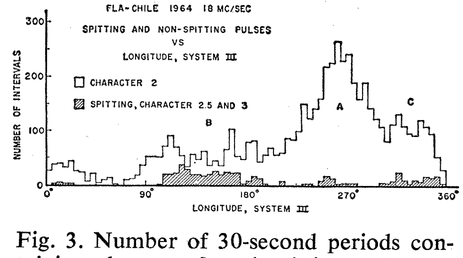

Fig. 3. Number of 30-second periods containing character-2 and spitting pulses, as a function of System-III longitude, for the 18-Mc/sec emission during the 1964 apparition. The shaded area represents spitting, while the unshaded area represents type-2 pulses.

total activity for sources B and C but less than one-sixth of the activity for source A; thus the average character number is depressed in the A region. It is encouraging that Baart, Lee, and Barrow (*4*) have recently reported results closely resembling those of Figs. 2 and 3, although their study was based on much less extensive data.

Comparison of Figs. 2 and 3 suggests that there may be a temporal

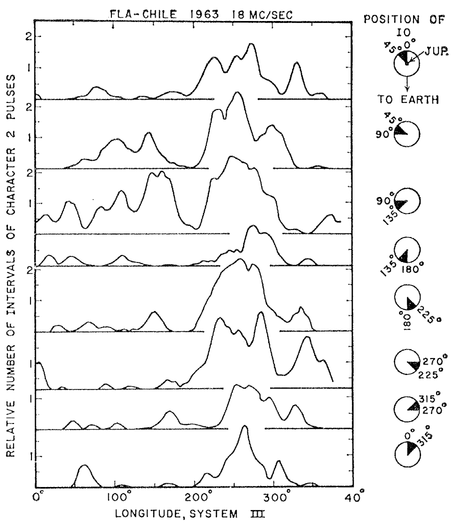

Fig. 4. Relative number of periods of 18-Mc/sec type-2 pulses as a function of System-III longitude for various positions of Io during 1963. Each profile represents the data received while Io was within the 45° shaded zone shown in the diagram at the right of that profile. Unity on the ordinate scale represents 25 30-second periods of radiation; three-point smoothing has been employed in the profiles in Figs. 4 and 5.

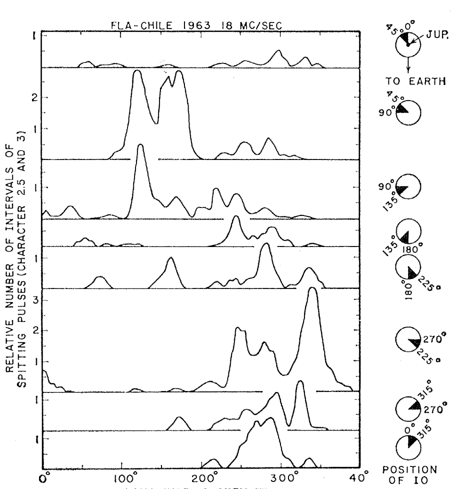

Fig. 5. Relative number of periods of 18-Mc/sec spitting pulses as a function of System-III longitude for various positions of Io during 1963. Unity on the ordinate scale represents ten 30-second periods of radiation.

variation in the relative amount of millisecond-pulse activity. In 1963 18 percent of all the 18-Mc/sec activity periods contained type-3 pulses, but in 1964 the figure dropped to 8.5 percent. The planet-wide average probability of emission for 18-Mc/sec pulses of all types declined from 0.173 in 1963 to 0.125 in 1964.

Since it is now well established that the position of the innermost Galilean satellite, Io, strongly influences the probability of Jovian decametric emission (*5*), an effort was made to see if this effect extends to pulse character. Figures 4 and 5 show profiles of 18-Mc/sec activity versus the System-III longitude of Jupiter's central meridian for normal and for spitting pulses, respectively; in each case the profile is drawn for eight different positions of Io relative to the Earth-Jupiter line. Figure 4 suggests that the type-2 activity of source A was relatively insensitive to the position of Io; while it shows the well-known enhancement when Io was roughly 90° or 240° from superior geocentric conjunction, a significant amount of activity was always present that was apparently unrelated to Io. On the other hand, Fig. 5 implies that the spitting activity from source A was somewhat more sensitive to the location of the satellite, peaking when Io was near western elongation; most striking of all is the sharp peaking of spitting activity in source B when Io was near 90°, and in source C when the satellite was near 240°.

The correlations demonstated in our studies can be used to support the hypothesis that the immediate environment of Jupiter itself must contribute in an important way to the burst structure. This point of view recently received additional encouragement from Riihimaa's report that the bursts from source B display a distinctive spectral fine structure (*6*). However, this conclusion should not be regarded as precluding interplanetary or ionospheric influences; for example, the mechanism responsible for generation and escape of the radiation may produce, among the several sources, disparate angular sizes or bandwidths. These factors, then, may well result in the radiation from each source interacting differently with the intervening medium.

C. N. OLSSON
ALEX G. SMITH

Department of Physics and Astronomy, University of Florida, Gainesville, and Maipu Radioastronomical Observatory, University of Chile, Santiago

References and Notes

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Luna 9 Pictures: Implications

Abstract. *Evidence from Luna 9 does not preclude the possibility that the moon may have a surface made up largely of very fine rock particles. The degree to which they attach to each other and the resulting firmness of the ground cannot yet be closely estimated.*

The successful experimentation with Luna 9 resulted in an interesting set of panoramic lunar surface pictures of high quality (see Fig. 1). The definition appears to be close to 1 mm for the nearest ground, and the illumination and range of gray scale is good enough to allow the detailed surface shapes to be seen. Owing to an unpredicted movement that took place some hours after the landing, views from different positions are available from which a stereoscopic picture can be constructed. Despite the clarity of this visual information, it seems to be impossible to make any definitive judgment concerning the mechanical properties of the soil or the processes responsible for the formations seen there.

Although the Soviet experimenters have asserted that the lunar surface is hard and dust-free, it is clear from their public statements (*1*) that they base this deduction on two observations: (i) the station did not sink appreciably into the surface, and (ii) the surface does not have the appearance which they expected of dust. In what follows we shall demonstrate that neither of these considerations excludes a dust-covered surface. The experimenters have also denied (*1*) having any instrumentation (such as soil-manipulating devices) on the station other than the television camera, a