LETTERS TO THE EDITORS

ASTROPHYSICS

Presence and Correlation of Fine Structure in Jovian Decametric Radiation

JUPITER'S non-thermal emission in the decameter region of the spectrum takes the form of sporadic radio noise storms having durations ranging from minutes to several hours[1]. Observers agree that the storms show fine structure, in part composed of bursts which typically have durations ranging from several tenths of a second to several seconds. However, there has not been agreement as to the presence of still finer structure or the intrinsic origin of any of the fine structure.

In 1956 Kraus[2] and Gallet[3] reported very short bursts having durations of tens of m.sec. or less, which they associated with Jupiter, but other observers[4-7] have been unable to confirm this. As for the origin of fine structure, radio sources of angular size much greater than Jupiter often show pronounced ionospheric scintillation with components occasionally as short as several seconds[8,9]; the Jupiter source must be expected to show at least similar effects. Recordings made by Gardner and Shain[4] on three nights in 1956, using receivers spaced 25 km. east–west, indicated little correlation of the noise fine structure over this base-line, the lack of correlation suggesting that ionospheric irregularities might account for much if not all of the burst structure. On the other hand, a spaced-receiver observation by us in 1958 (ref. 10), while confirming the existence of considerable amplitude distortion, showed 80 per cent correlation in the time of arrival of bursts at stations separated by as much as 30 miles east–west. Florida–Chile observations in 1960 by A. G. Smith and Carr[11] also indicated partial correlation over a very long base-line, suggesting the reality of some intrinsic fine structure.

To resolve these questions a new series of base-line correlation observations was initiated by us in March 1961. Four identical crystal-controlled total-power receivers working at 22·200 Mc./s. with 6 kc./s. band-width were fed with identical antennas. The locations chosen were the Yale Observatory's Bethany Observing Station (central site), Hendrie Hall at New Haven (15 km. south of Bethany), Van Vleck Observatory at Middletown (30 km. east of Bethany), and Pomfret School (100 km. east of Bethany). The audio outputs of the receivers were transmitted to Bethany on telephone lines. During Jupiter storms all four channels plus timing marks were recorded on a high-speed photographic recorder with a time constant of 30 msec. Records obtained on 19 nights up to August 1 exhibited various degrees of correlation, including 6 nights on which correlation was essentially perfect, without amplitude distortion. Correlation tended to improve through the Jupiter observing season from March onwards, suggesting that the phase with respect to Jovian opposition (July) or to the terrestrial season (summer) may be significant.

A small portion of a storm with correlated events (July 18) is reproduced in Fig. 1 (the New Haven receiver was not functioning during this run). Storms with similar portions of closely correlated events were observed on June 5 and July 11, 20, 27, and 30. No form of ionospheric effect is known that preserves its correlation over 100 km.; accordingly we conclude

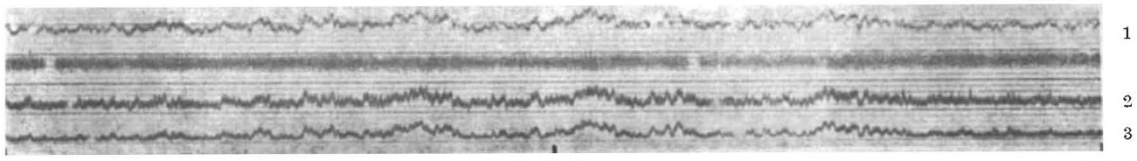

Fig. 1. A 20-sec. portion of the high-speed recording of the Jupiter storm of July 18, 1961, showing close correlation of fine-structure events received at Middletown (3) and Pomfret (2) stations separated by 30 and 100 km. respectively from the Bethany Station (1)

that fine structure such as that of Fig. 1 is characteristic either of the source at Jupiter or of the interplanetary medium, but that this intrinsic structure is often largely obliterated by local ionospheric effects.

During this observing season we noted the presence of numerous correlated fine-structure components having durations of hundredths rather than tenths of seconds. In comparison, our observations during 1960 showed no events having durations less than 0·1 sec. We must regard this extreme fine structure as real, in view of its correlation over long base-line and association with Jupiter storms (not present before or after). Thus the occasional existence of Jupiter bursts of extremely short duration as reported by Kraus and Gallet seems to be confirmed.

The co-operation and assistance particularly of E. Milone of Yale Observatory, Dr. F. Zabriskie of Van Vleck Observatory, J. McCullough of Pomfret School, and financial support from the National Science Foundation are gratefully acknowledged.

JAMES N. DOUGLAS
HARLAN J. SMITH

Yale Observatory,
135 Prospect St.,
New Haven, Connecticut.

[1] Smith, A. G., *Science*, **134**, 587 (1961).
[2] Kraus, J. D., *Astro. J.*, **61**, 182 (1956).
[3] Gallet, R., *Inst. Rad. Eng. Trans. on Antennas and Propagation*, 327 (July 1957); also private communications.
[4] Gardner, F. F., and Shain, C. A., *Austral. J. Phys.*, **11**, 55 (1958).
[5] Carr, T. D., Smith, A. G., Pepple, R., and Barrow, C. H., *Astrophys. J.*, **127**, 274 (1958).
[6] Douglas, J. N., thesis, Yale University (Sept. 1960).
[7] Smith, H. J., Lasker, B. M., and Douglas, J. N., *Astro. J.*, **65**, 501 (1960).
[8] Lawrence, R. S., and Jespersen, J. L., *Nat. Bur. Stand. Tech. Note*, No. 20 (July 1960).
[9] Warwick, J. W., *Ann. New York Acad. Sci.* (in the press).
[10] Smith, H. J., and Douglas, J. N., *Paris Symp. Radio Astronomy*, 53 (Stanford Univ. Press, Stanford, Calif., 1959).
[11] Smith, A. G., Carr, T. D., Bollhagen, H., Chatterton, N., and Six, F., *Nature*, **187**, 568 (1960).