Planetary Radar

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This article reports on the radar astronomy activities supported by the Deep Space Network (DSN) during the unique close approaches of the comets IRAS-Araki-Alcock (1983d) and Sugano-Saigusa-Fujikawa (1983e) to Earth.

I. Introduction

The application of modern planetary radar techniques to a comet passing in close proximity to Earth has the potential to determine the nature of cometary origins, structure, and internal dynamics. Moreover, the understanding gained could very likely negate or corroborate one of the prevailing hypotheses regarding the origin of the solar system: that comets are the remainder of the primordial material out of which the planets coalesced approximately 4.5 billion years ago.

In 1983, two unique opportunities were presented to observe a comet very near to Earth. The last such encounter was several centuries ago.

II. Observations

A. IRAS-Araki-Alcock

The first event came in May with the arrival of the comet IRAS-Araki-Alcock (1983d). The Point of Closest Approach (PCA) was measured at about 0.03 Astronomical Units (AU). Two observing sessions were scheduled, amounting to ten hours of supported activity at DSS 14. Observations at S-band produced strong radar echoes and about seven viable spectra. Indeed, the return signals were monitored in real-time with a good signal-to-noise ratio, and subsequent observations at X-band were made at orthogonal circular polarizations.

Preliminary data analysis is speculative at best, but some conclusions can be drawn. The spectral features (see Fig. 1) indicate a rapid rotation of the comet's nucleus, and a spin period of 1.6 hours is suggested. Since the spectral bandwidths define the pole positions (north and south), one can then infer a radius of approximately 200 meters (m). Therefore, the geometric cross section corresponds to:

$$\sigma_g = \pi(200\text{m})^2 = 1.2 \times 10^5 \text{ m}^2$$

However, the measured radar cross section, σ_r, is about 5×10^6 m^2, leading to an albedo, a, of

$$a = \frac{\sigma_r}{\sigma_g} = \frac{5 \times 10^6 \ m^2}{1.2 \times 10^5 \ m^2} \cong 40$$

An albedo of 20-30 might be explained on the basis of cometary debris in the coma, but the residual discrepancy is difficult to account for. Alternatively, if the spectral features are *not* real, but due to speckle noise, one is forced to assume a much longer spin period. In that case, the surface albedo is unknown since the radius cannot be determined. The shape of the power spectrum and the depolarization ratio (~25%) of the return signals imply that the majority of the surface is rough on a large scale, but smooth on a scale comparable to a wavelength or smaller. Further analysis should yield a more definitive picture.

B. Sugano-Saigusa-Fujikawa

In June, a second comet, Sugano-Saigusa-Fujikawa (1983e), neared Earth with a PCA of 0.06 AU. S- and X-band observations were performed at DSS 14 for a total of 40 hours. No signals were observed in real-time; however, further data reduction and analysis may provide a detectable echo. A future issue of this publication will contain more information pertaining to the investigation of this comet.

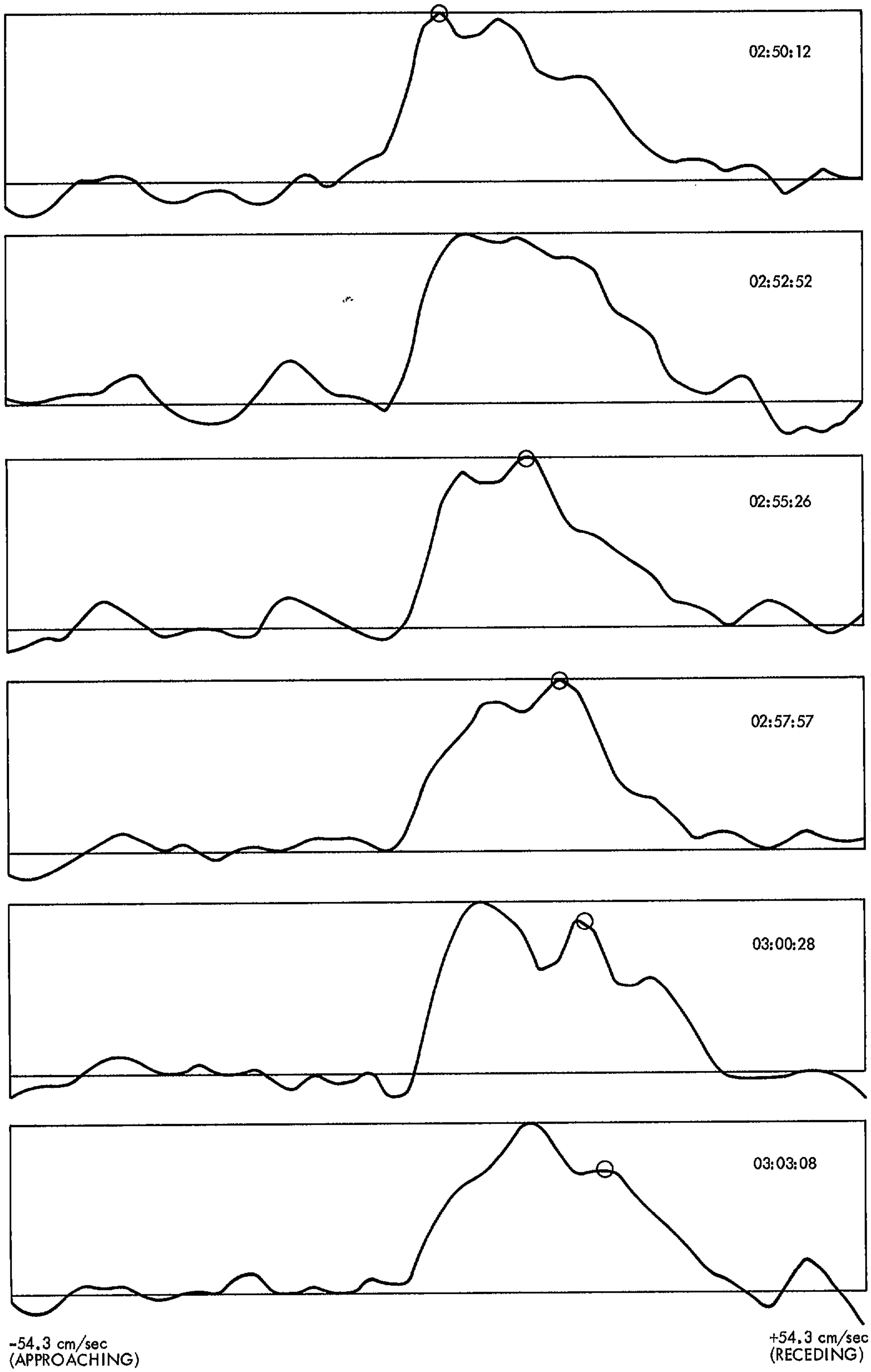

Fig. 1. Successive X-band radar spectra of Comet 1983d, showing the transit of a suspected spectral feature (circled) with respect to time. Abscissa is limb velocity. Ordinate is intensity