LUNAR RADAR CROSS SECTION AT LOW FREQUENCY. P. Rodriguez\textsuperscript{1}, E. J. Kennedy\textsuperscript{1}, P. Kossey\textsuperscript{2}, M. McCar
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Introduction: Recent bistatic measurements of the lunar radar cross-section have extended the spectrum
to long radio wavelength. We have utilized the HF Active
Auroral Research Program (HAARP) radar facility near Gakona, Alaska to transmit high power pulses at
8.075 MHz to the Moon; the echo pulses were received onboard the NASA/WIND spacecraft by the WAVES
HF receiver. This lunar radar experiment follows our previous use of earth-based HF radar with satellites to
conduct space experiments \cite{1}. The spacecraft was
approaching the Moon for a scheduled orbit perturbation
when our experiment of 13 September 2001 was
conducted. During the two-hour experiment, the radial
distance of the satellite from the Moon varied from 28
to 24 R\textsubscript{0}, where R\textsubscript{0} is in lunar radii. The figure below
shows the geometry of the experiment, in the solar
ecliptic plane.

Measurements: HAARP pulses with widths of 100-
ms and pulse periods of 500 ms provided about 12,000
data samples of the direct and echo radiowaves inte-
grated over 20 ms. From these pulse-echo pairs we ob-
tain the lunar radar cross-section using the radar equa-
tion. We obtain an average cross-section of about 15%
of the geometric cross-section, with maximum values of
about 50%. Previous determinations \cite{2}, \cite{3}, of the lunar radar
cross-section at shorter wavelengths have sug-
gested an increase of the cross-section with increasing
wavelength. Our measurement confirms this depend-
ence and extends the spectrum of lunar radar cross-
sections to a wavelength of 37 meters.

The HAARP-WAVES experiment provided evidence of high reflectivity locations on the lunar surface
that may be associated with topographical features that preferentially return an echo signal to the satellite. The motion of the spacecraft apparently changed the aspect sufficiently to allow several such regions to be sampled. The following figure illustrates a 5-second interval of data showing the direct HAARP pulses and the echo lunar pulses as received by the WAVES instru-
ment.

Conclusion: This new technique for long wave-
length radar cross-section measurement is free of scin-
tillation effects caused by the earth's ionosphere and
provides a relatively clean measurement of the lunar
cross-section. High power long wavelength ra-
dars, such as HAARP, can enhance our methods of
lunar research. We suggest that future lunar radar ex-
periments with lunar-orbiting spacecraft can provide a
new window on lunar topography and subsurface con-
ductivity measurements.

References: \cite{1} Rodriguez P. et al. (1998), \textit{Geophys.
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