Virtual Research Presentation Conference

2-D Steerable Submillimeter-Wave Antenna for Planetary Wind Measurements

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Program: Topical

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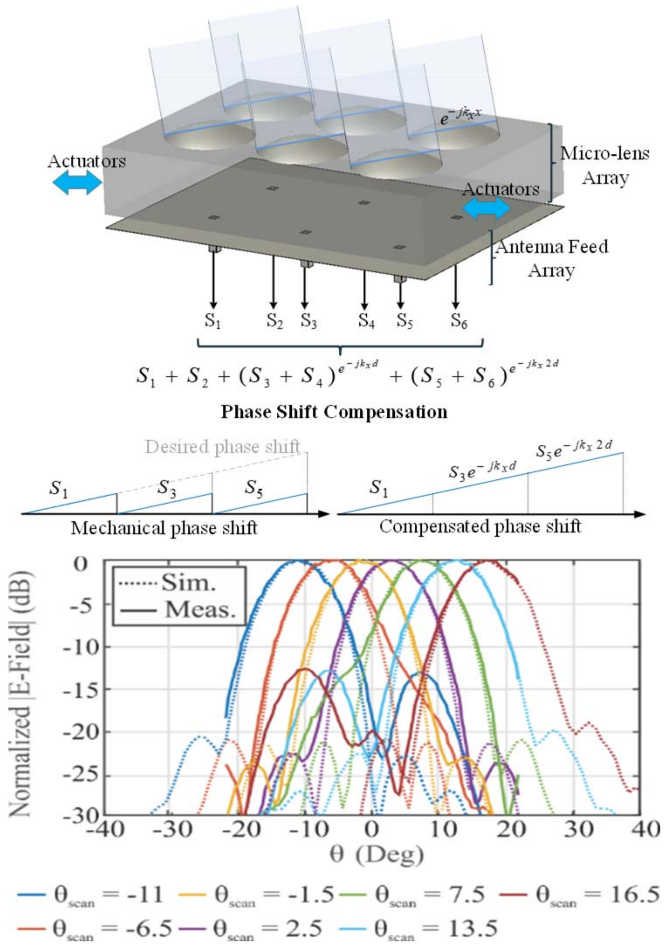
Introduction

- **We are developing an electronically steerable antenna at submillimeter-wave frequencies that does not require motors or gimbals.**
- **This development will noticeably reduce mass, volume, and power requirements and will have significant impact on the way submillimeter-wave instruments are built for planetary, Earth-science, and astrophysics applications.**
- **The intended outcome is to determine if 2D scanning of a sub-reflector retains appropriate science and risk postures, while reducing mass and complexity; a significant outcome would be the ability to propose a scanning sub-reflector sub-mm instrument for the Next Mars orbiter call.**



Scientific Motivation

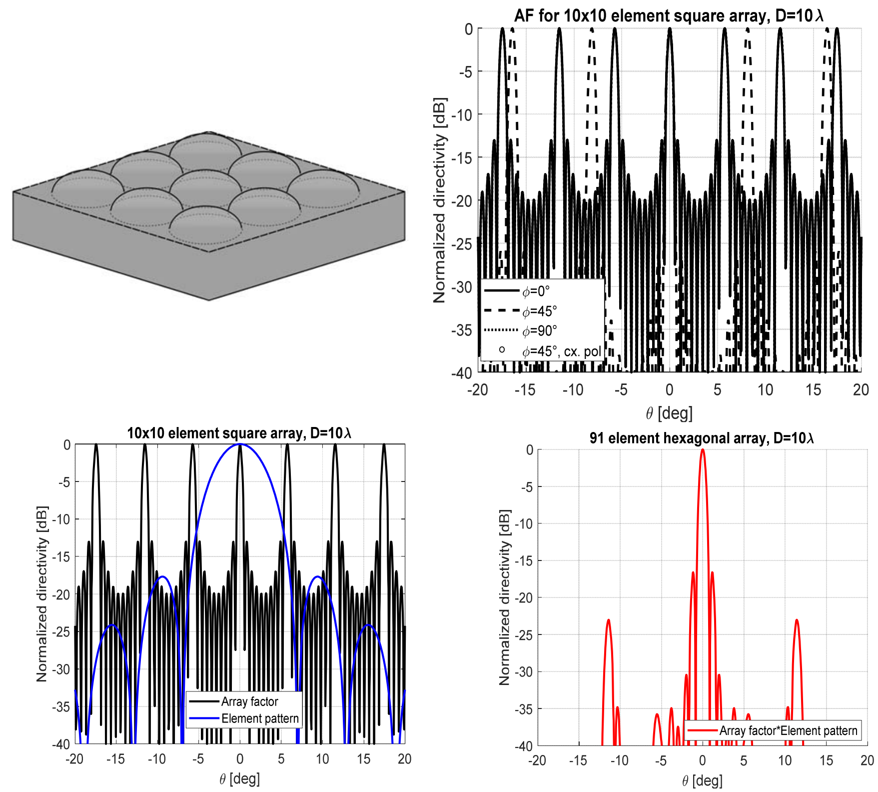
- Global, vertically resolved measurements of wind co-located with atmospheric temp, water vapor and, perhaps, other species is a high-priority outstanding need for the Mars atmospheric science community.
- This group also identified a submillimeter limb sounder as an ideal instrument for obtaining such measurements.
- The requirement is to measure 2D vector winds (north-south and east-west)
- The requirement is also to view as wide a range of latitudes as possible for important polar measurements, and to mitigate against science loss induced by the intent for the next orbiter to switch between sun-synchronous and precessing, lower inclination orbits roughly halfway through the mission.
- It is needed to avoid potential, frequent interruption in observation resulting from spacecraft maneuvers needed to point the planned high-resolution camera instrument.

Technology Status and Future Need

- The shortcomings of existing systems at these frequencies is that 2-D scanning is accomplished by articulating the primary reflector with power hungry motors and associated mechanisms.
- A new, innovative, and bold beam scanning antenna system at submillimeter-waves is needed, replacing conventional 2D scanning of primary (30-cm or larger) reflector systems.
- The scanning system will consist of a novel lens array antenna system with integrated piezo-electric actuator based translation stage, accomplishing beam scanning of $\pm 20^\circ$ both in horizontal and vertical directions. This will meet the science requirements.

Technical Approach

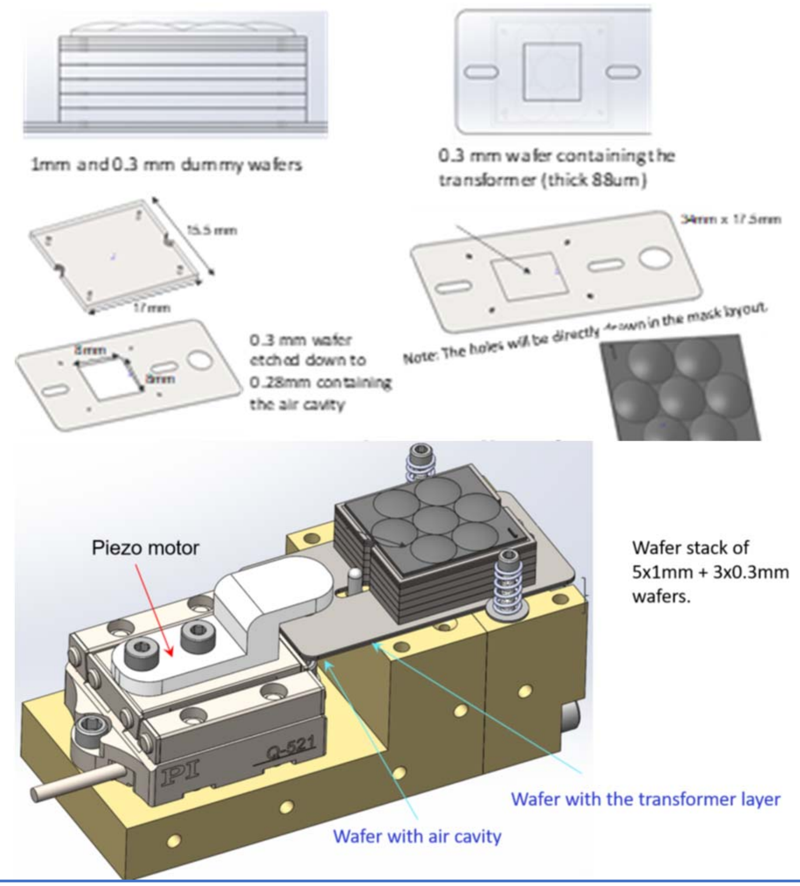
- The system design relies on compromise between the scanning angle range and gain reduction in the system resulting from aperture phase error and power spillover due to the translation of the sub-reflector.
- An array of shallow silicon lenses that are efficiently illuminated by a planar waveguide based antenna.
- The beam-scanning is performed by translating the array of shallow lenses with one small and light piezo-electric motor (size of 2cm x 3cm x 1cm).
- We will develop a sparse phased array of receivers that uses a novel coupling architecture that is compact (< 5cm thick), wideband (fractional bandwidth is > 30%) and can perform beam scanning over a field of view of ±20° with low loss (< 1dB).



Sparse array of elliptical lenses with diameter Dlens >> λ/2 and the grating lobes they create. The impact of the grating lobes can be reduced by element pattern as the resulting array pattern is the product of the array factor and element pattern.

Accomplishments

- Created a sparse array of elliptical lenses with diameter D_{lens} >> λ/2. The sparse array (under-sampling) causes grating lobes in the array factor. However, the impact of the grating lobes can be reduced by the element pattern.
- Optimized the required *f#* of the system. The dependence on the *f#* of the scan angle of the secondary pattern can be estimated. This will result in ≈2 dB scan loss. Therefore, the design goal is to reduce the lens's *f#* to achieve larger scan angles.
- Also optimized the required ε_r needed for the matching layer of the lens system.
- In the process of fabricating the array now.



Final design of all the components for the lens array, leaky-wave feed, and the impedance matching layer for the scanning antenna array and the CAD of the prototype array.

Significance of Results

- **This work, when completed, will save mass and power for instruments measuring winds on Mars.**
- **An electronically steerable antenna at submillimeter-wave frequencies that does not require motors or gimbals will noticeably reduce mass, volume, and power requirements and will have significant impact on the way submillimeter-wave instruments are built for planetary, Earth-science, and astrophysics applications.**