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A Preliminary Design Study for an Affordable 12 Metre Carbon Composite Radio Telescope

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Abstract

Carbon composites are ideal materials for geodetic VLBI antennas. They allow structures to be fabricated that are simultaneously light and stiff. In terms of antenna design, this translates into a reflector surface that exhibits minimal gravitational (or wind) deflection. If the back support structure, the yoke, and the pedestal are also fabricated from carbon composites, the low coefficient of thermal expansion minimizes annual (and diurnal) thermal height signatures along with tilts due to differential solar irradiation.

A preliminary design study has been undertaken to determine the feasibility of constructing an affordable 36 GHz carbon composite radio telescope, which also has high thermal stability and high slew rates. The conclusion is that such a telescope can be produced. Material and labour costs for a prototype telescope come in at values less than fabricated metal telescopes; and, although economies of scale are important, the numbers at which the process becomes feasible are much smaller than for other processes such as hydroforming.

The telescope has a very lightweight all carbon composite structure. The dish, together with its supporting beams is molded as a single unit using a new composite manufacturing process. Using this process, together with an optimized composite structural design, both the labour and material costs can be kept low. Such a structure can be designed to be wind dominated rather than gravity dominated. In this way a very lightweight structure can be produced that performs well at 36 GHz under some lesser wind condition, with the requirement for stronger winds being survival alone. Alternatively the telescope can be designed to perform in full wind (say 30 mph) at 36 GHz or higher. The limitation is strictly weight and cost.

Since the antenna structure will weigh about 15% of a typical all-metal design, achieving high slew rates will be considerably easier. An innovative option for achieving very high slew rates is to use brushless linear motors. This type of drive system exhibits zero wear because it has no contacting parts. It also has very low inertia and zero backlash. With this type of drive system, full sky slewing times on the order of 20 to 30 seconds are easily obtained. The cost increase for linear drives over conventional geared drives is not large when compared to the total cost of the telescope.