

Kilometre-square Area Radio Synthesis Telescope

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Abstract

A Five hundred meter Aperture Spherical Telescope (FAST) is proposed to be built in the unique karst area of southwest China, and will act, in a sense, as a prototype for the Square Kilometre Array (SKA). It will be over twice as large as the Arecibo radio telescope coupled with much wider sky coverage. Technically, FAST is not a copy of the existing Arecibo telescope but has rather a number of innovations. Firstly, the proposed spherical reflector, by conforming to a paraboloid of revolution in real time through actuated active control, enables the realization of both wide bandwidth and full polarization capability while using standard feed design. Secondly, a feed support system, which integrates optical, mechanical and electronic technologies, will effectively reduce the cost of the support structure and control system.

Introduction

There are various concepts to realize the SKA project (see details at <http://www.skatelescope.org>). Chinese astronomers are going to build a set of large spherical reflectors by making use of the extensively existing karst landforms, we refer this as Kilometre-square Area Radio Synthesis Telescope (KARST) approach. KARST would be consisted of about 30 individual elements, each of roughly 200 m in diameter. As a forerunner for the KARST, the FAST is planned to be constructed as a National Megascience Project of China, with an estimated cost of ~60 M US\$ around the year 2006.

FAST reflector, as shown in Fig.1, is a spherical cap with a radius of $R \sim 300\text{ m}$ and an opening up to 500 m in diameter. The effective aperture of $\sim 300\text{ m}$ is illuminated by the feed moving on the focus surface halfway from reflector to its center. It will enable the FAST to have a larger sky coverage ($> 40^\circ$ zenith angle) than the Arecibo telescope ($\sim 20^\circ$ zenith angle), and the simplified feed system will continuously cover most of the frequency range between 100 and 2000 MHz, with capability up to 5 or even 8 GHz depending upon the cost. The illuminated part of the main spherical reflector is to be continuously adjusted to fit a paraboloid of revolution in real time by actuated active control, synchronous with the motion of the feed while tracking an object. Each element has three actuators to fix its position and connect it with adjacent elements, and there would be an average of one actuator per element, as shown in Fig.1. The support with its actuator is directed towards the center of the sphere. Alternatively, an antenna surface supported by cable net like Arecibo telescope could be activated in some extent without extra-servos controlling the lengths of those supporting ropes. And the integrated length indicating the deformed parabola is only 0.36 m shorter than the spherical curve, about one in a thousand of the total length. This small difference required by deforming could be achieved within the elasticity of ordinary wire ropes, although the mechanical analysis is much more intricate.

FAST can be seen as an "Arecibo-type with active main reflector", the telescope is "pointed" by moving the feed cabin, while the reflector surface is deformed in synchronism with the feed pointing motion.

A new design for the feed-support structure, as demonstrated in Fig. 2, has been proposed by using six suspended cables connected to mechanical servo-control systems. Compared with the Arecibo 305 m radio telescope, the total weight of the feed support system could evidently be reduced by 2 orders or more with such a design. The tracking will be by means of integrated mechanical, electronic and optical technologies, i.e., optomechatronics. Alternatively, a small cable car, to serve as the focus cabin housing the feed and receivers, is to be driven by eight cables. The cable-car configuration is demonstrated in Fig. 3. Two pairs of parallel supporting cables will be suspended from two pairs of opposite towers, while another four downward cables are securely fastened to four anchors which are symmetrically arranged about the main spherical reflector. The lengths of the connecting cables would be adjusted appropriately as the cabin location changes. Such a design aims to increase the stiffness of the platformless cable support structure discussed above. Trim masses can be used to balance the static load of the suspension cable for energy efficiency during operation of the telescope. Positioning of the cabin would be achieved by driving the car on two crossed sets of supporting cables, which is like a trolley on the cable-way in mountains.

The collecting area of a telescope is a figure of merit of that instrument's capability. FAST would provide the first opportunity to investigate in some detail the pulsar population in another galaxy, will be effective in deep surveys for sources such as rare types of pulsars and neutral hydrogen clouds at moderately high red-shifts. Details in the structure of individual pulses, or in their polarization, might be vital. Such measurements rely on raw sensitivity: a single pulse can only be observed once. It should be remembered that if we have twice as much sensitivity, for uniformly distributed object we will look twice as far in space, and should find eight times as many objects. The FAST obviously will achieve, as a single dish, the largest collecting area in the world.

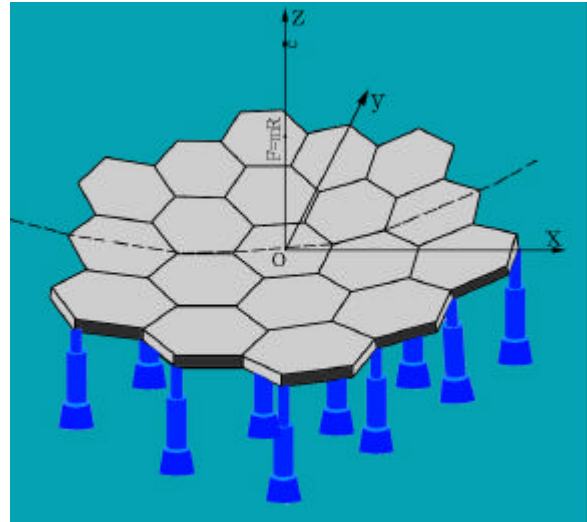
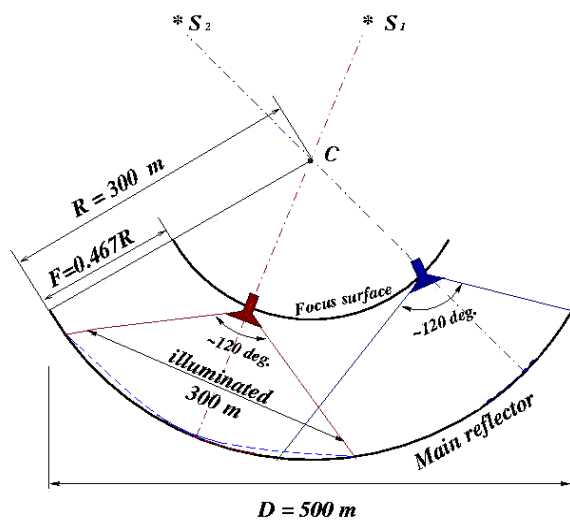


Fig.1 FAST geometrical configuration and active reflector

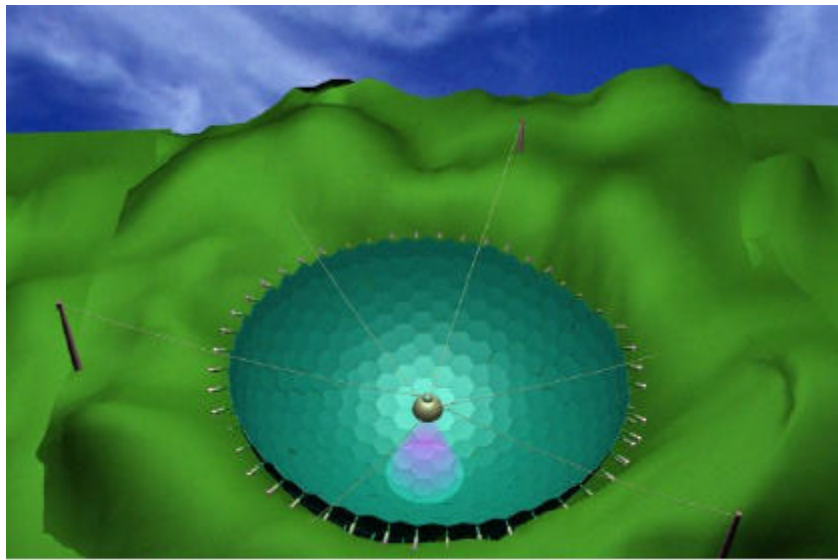


Fig.2 Cable support system without a platform and FAST concept

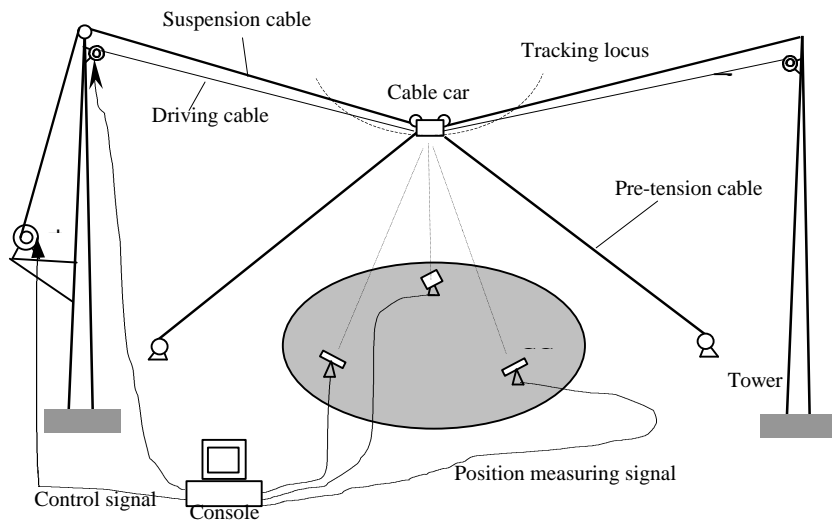


Fig. 3 General assembly of the cable car feed support configuration