Korea Array Radio Telescope in the Low Frequency Radio Sky

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Abstract

Korea Array Radio Telescope (K-ART), a prototype radio array telescope in Korea, is designed for 300−450 MHz wavebands. The system is under construction in the Jeju Island of the South Korea, and is currently in its testing mode since mid-October 2010. It is primarily designed for monitoring solar activity and radio transients. K-ART has a capacity to monitor transients for about 4−5 hours per day, with a spatial resolution of about 10 minutes and a timing resolution of milliarcseconds. The sensitivity is expected to be a few mJy or less. We expect to monitor radio transients such as X-ray binaries, cataclysmic variables, quasars and flare stars, on the target-of-opportunity mode, in addition to the scheduled observation.

Key words: instrumentation: interferometers, telescopes — radio continuum stars: Sun, flare stars, cataclysmic variables, X-ray binaries — quasars — education: astronomy and astrophysics

1. Introduction

Recently, a few low frequency radio arrays such as the Low Frequency Array (LOFAR: Garrett 2009) and Murchison Wide-field Array (MWA: Cappallo et al. 2007) have been launched for a long wavelength of a few to tens of meters, or tens to hundreds of MHz, one of the most poorly explored in the electromagnetic spectrum. As a reflection of this trend, Koreans recently initiated the first low frequency array and named it Korea Array Radio Telescope (K-ART).

K-ART will cover a different low frequency radio wavelength of 300−450 MHz from other facilities such as LOFAR (30−240 MHz) and MWA (80−300 MHz). K-ART project is arranged and operated by the Radio Research Agency of the Korea Communication Commission. K-ART is building based on the digital signal processing for interferometer similar to LOFAR and MWA. K-ART will be locate in the Jeju Island, the largest Island of tourism and orange farms in South Korea (Figure 1).

2. Design Overview

K-ART system will be operated in the frequency range of 300−450 MHz with a band width of 10−20 MHz. There are separate continuum and spectrum modes. Dual polarization is equipped. The field of view is planned to be 80°(North-South)×80°(East-West) or, alternatively, 10°(North-South)×10°(East-West), depending on observational modes. The beam size, or angular resolution, will be primarily 10 minutes with further improvement later on. The collecting area is initially designed to be 1,000 m^2 in the first year of the operation, and will be improved to 2,500 m^2 in the second year of the project. K-ART has a capacity to monitor a transient for about 4−5 hours per day, with a spatial resolution of 10 minutes and a timing resolution of milliarcseconds. The ideal temperature of receiver would be ∼100 K. The desired point source sensitivity with 3σ is ∼10 mJy for the integration time of 100 seconds. The expected time resolution will be 1 millisecond or less. Three observing modes have been suggested: phased array mode for solar wind monitoring, interferometer mode for radio sky imaging, and both modes for radio transients.

There are a few technical issues under discussion: radio frequency interface, antenna and beam pattern, phase control, data rate and storage, correlation process, clock synchronization and trigger. In the phase control, there will be two ways: software and beam former. The data rate is expected to be ∼2 Gbytes/s. About 30 Tbytes are expected for storage. The software correlation will be developed.

3. Key Science

The Radio Research Agency was originally interested in the study of solar wind, as one of the space weather indicators in the radio range and wanted to develop solar wind monitoring system. Further astrophysical topics

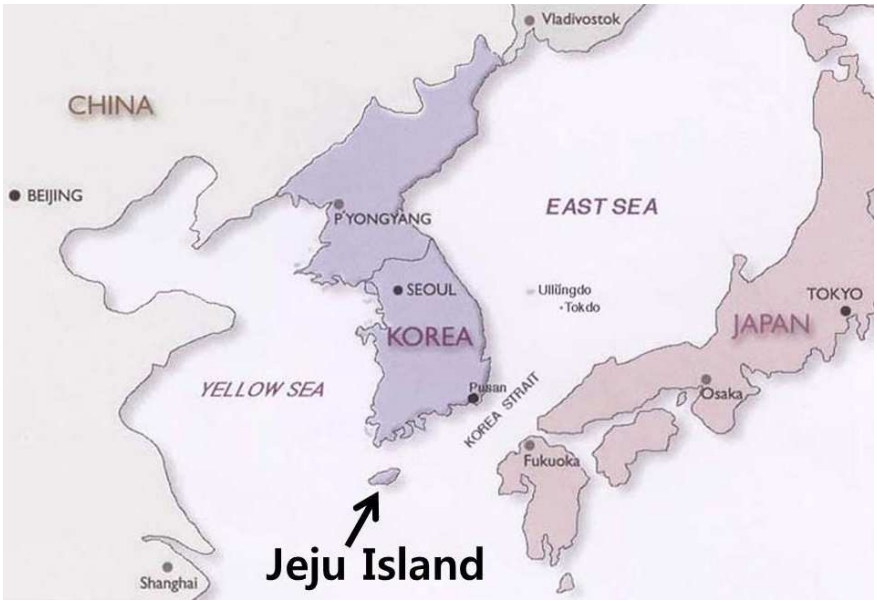

Fig. 1. The location of K-ART. The system will be located in the north-western side of the Jeju Island, South Korea.

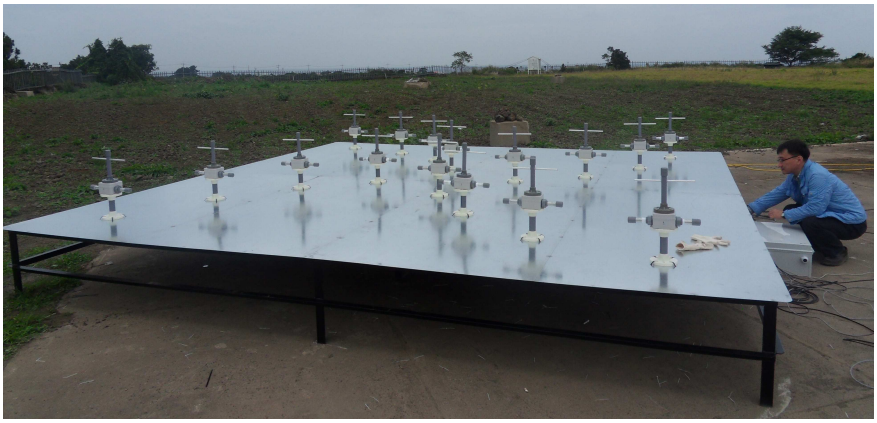

Fig. 2. A prototype of a tile for K-ART tested in 14−15 October 2010 at the Jeju Island site. One tile consists of 4×4 dipole antennas.

as Key Science Projects have been included as collaborated with astronomical society of Korea. Since K-ART is set up in different geographical location from other low frequency array in other continents, we expect that it will play a compensating role in timing monitoring, for example, to LOFAR in Europe and MWA in Australia. The tentative, proposed topics of Key Science Projects for K-ART are:

- Solar wind monitor and imaging
- Sun imaging
- Radio transients
- Wide filed imaging of radio sky

The detailed topics of radio transients are under discussion. All available variable and transient sources such as flare stars, cataclysmic variables, X-ray binaries and quasars can be possible as far as the instrument can meet the detectability of these sources, similar to one of the Key Science Projects of LOFAR (e.g., Fender et al. 2007). The daily monitored data can be also utilized as materials for education in astronomy and astrophysics, and for public outreach.

4. Current Status

On October 2010, a prototype of 3 tile-system was tested at the Jeju Island Campus of Korea Radio Agency. The one tile corresponds to 4×4 dipole antennas (Figure 2). Typical astronomical objects like the Sun and bright quasars were monitored. Test with about 1,500 antennas will be performed in the Jeju Island site during 2011. In the second year of 2012, a full set of 2,500 antennas will be operated.

The completion of K-ART is expected by the end of

2012. We expect the K-ART will be an East Asian site for monitoring of radio transients in the low frequency radio arrays along with similar systems in other continents. In particular, K-ART will observe different waveband of 300−450 MHz from other low frequency radio arrays such as LOFAR ($\leq$ 240 MHz) and MWA ($\leq$ 300 MHz). Like other low frequency radio arrays, K-ART can be a test bed for the Square Kilometer Array, SKA (Park 2010), designed for the frequency range from 70 MHz to 10 GHz, or up to 25 GHz later, in the first and second phases for full science operations scheduled in 2020 and 2024, respectively (http://www.skatelescope.org).

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