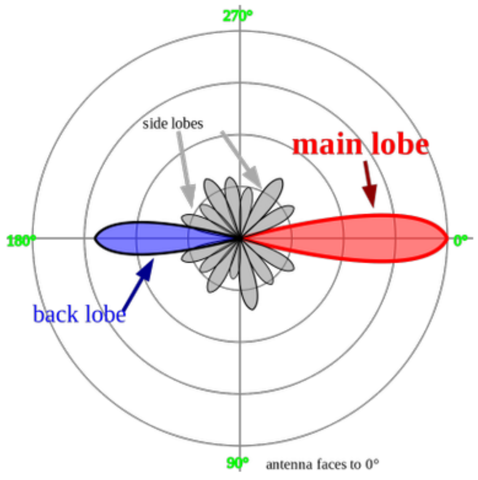
Toward super-resolution mapping of radioastronomical data

Spectroscopy in the radio electromagnetic domain is one of the most fruitful observational methods in astrophysics. It opens the way to a wealth of diagnoses, from chemical composition to gas dynamics of comets, interstellar clouds, circumstellar envelops, or galaxies.

Similarly to an optical telescope, a limitation of radioastronomical mapping originates mainly from the diffraction pattern of the main mirror, but the greater size of radio wavelengths makes it a more substantial limitation. In addition to the limited angular resolution, the specificities of radio antenna diffraction patterns imply that the main beam of the telescope (analogous to the Airy disk) only corresponds to typically ~50% of the antenna response, while the rest of the response comes from the secondary beams (“side lobes”), so that the signal observed toward a source also depends on the emission of its surrounding in a way that cannot be easily anticipated.

In this project we aim to characterize the magnitude of this effect on actual data obtained with the Taeduk radioastronomy observatory (TRAO) 14-m telescope (South Korea). In a first step, the student will propose an observational scheme based on the observation of a bright point source to measure the antenna diagram, i.e. the response of the telescope to point sources as a function of the angle between the antenna pointing direction and the source location. If the proposal is accepted by the TRAO staff, the telescope will be used remotely from the Besançon observatory to measure the real antenna diagram of the TRAO 14-m telescope. In a second step, using the obtained antenna diagram (or a mock realistic one, in case observations are not allowed), a numerical program will be developed to simulate observed maps distorted by the antenna response. Comparing the original maps with the simulated maps, the effects of distortion will be quantified for various situations to evaluate the need for deconvolution to compute super-resolution maps.



Left: A typical antenna diagram. The pointing direction of the antenna is to the right. Right: The TRAO 14-m telescope, from inside the radome.

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