

## Masers

The word "maser" is an acronym for Microwave Amplification by Stimulated Emission of Radiation. Masers are the long-wave equivalent of lasers; emitting in the microwave, rather than the visible part of the electromagnetic spectrum. Both systems rely on a species with an excited energy-level population being stimulated into lower energy levels, either by photons or collisions with other species. The first laboratory maser was constructed in 1953 by Charles Townes and Arthur Schawlow and based on idea of stimulated emission first proposed by Albert Einstein.

In 1965 the first cosmic maser was discovered, in a region of OH gas close to a young star. Since then, many hundreds of cosmic masers have been observed, giving us an insight into the physical conditions in a large range of astronomical regions.

Cosmic masers are very bright radio sources which can be studied with high angular resolution using MERLIN and VLBI. They are pumped by energy from the central object (e.g. a young star, red giant or active galactic nucleus). The maser emission, due to its long wavelength is able to provide information on dusty regions which are undetectable at almost all other wavelengths.

The cosmic masers we study at Jodrell Bank are clouds of gas and dust, containing excited molecules of hydroxyl (OH), water (H<sub>2</sub>O), methanol (CH<sub>3</sub>OH) and formaldehyde (CH<sub>2</sub>OH). The spectral line emission is typically amplified millions of times by the maser process, making them visible over much larger distances.

The sites of maser emission include:

- Comets
- Star-forming regions
- Circumstellar envelopes of red giant stars
- Supernova remnants
- Discs in the centres of active galaxies