Maser observations with VLBI

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Astronomical masers and Very Long Baseline Interferometry (VLBI) are tightly connected, owing to the large amplification factors of masers causing very compact emission regions. In this presentation we will address, and high light, a wide range of science cases where spectral-line VLBI maser observations have provided detailed insight into dynamics and physical conditions. Galactic maser observations of primarily OH, H_2O and CH_3OH have revealed disk and outflow structures in star forming regions (SFRs), and SiO transitions have been instrumental to trace the envelopes around evolved stars. As different transitions in a given molecule and its isotopologues can probe slightly different physical conditions, (near)simultaneous observations of a set of transitions can give information about the gas temperature and density as a function of position in the source. In evolved stars, maser polarization observations have further begun yielding measurements of the magnetic field, although the samples yet are too small to completely clarify the role the magnetic fields may play in, e.g., the formation of planetary nebulae. Provided with the high angular VLBI resolution we further have access to precision astrometry, and indeed masers are used to map the structure of the Milky Way. Extragalactic maser observations have been dominated by H_2O and OH, where the H_2O mostly is related to the accretion disks around super-massive black holes. While most VLBI science has focused on transitions in the cm regime, there is now also a rapidly growing interest and need for mm-VLBI maser observations following the recent multitude of mm wavelength maser detections of, for example, H_2O and SiO.