Use of 1-D D_α camera to measure the density gradients in spherical tokamaks

Abstract

One of the clearest signatures of transitions from L-mode to H-mode plasmas is the steepening of the edge density gradients. A concomitant narrowing of the visible radiation, often dominated by Balmer D_α emission, is generally observed. A means of extracting electron densities from this narrowing of the radial D_α emissivity profile was pioneered on the START device and developed further on MAST. It takes advantage of the near insensitivity to electron temperature of both the ionisation and emission rates of hydrogen at temperatures well in excess of the ionisation potential (13.6 eV). For example, population rates to the n=3 principal quantum level, for D_α emission, vary by only 15% for Te=40eV to 300eV, typical of MAST edge plasmas. The D_α emissivity profile is obtained from spatial inversion of line-of-sight integrated intensities recorded by a linear camera (Δt = 125μs, 256 pixels). Typically, the D_α emissivity width (FWHM, Δ_α) is 4-6cm for L-mode, similarly for ELMs, and 1-3cm for H-mode MAST plasmas, comparable with typical edge n_e scale lengths.
Two models are used in the interpretation of the D_α emissivity profiles. The first is an analytic one, giving simple relationships between emissivity widths and the associated electron and neutral densities and their gradients, at peak emissivity, and thus suitable for rapid data-analysis and online plasma position control. The second model is computational and incorporates a Monte-Carlo neutral particle treatment and a more detailed description of plasma parameters, including temperature, density and neutral particle influx profiles. The 300 point Thomson scattering diagnostic has been used as a yardstick in comparing experimental data from a wide range of edge density gradients and a range of edge temperatures in checking the models validity and assumptions.