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THE VELOCITY DISTRIBUTION OF NEUTRAL PARTICLES IN THE ARC OF A HOLLOW CATHODE DISCHARGE

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We investigated the velocity distribution of the neutral particles in the arc of a low pressure (10^{-3} torr), hollow cathode ($T_c \simeq 2500$ K), magnetically confined (0.2 - 0.4 T) discharge (20 - 150 A) in argon by measuring the profile of the $\lambda = 696.5$ nm line with a Fabry-Perot interferometer (apparatus halfwidth value : 30 mÅ). The spectral lines emitted by this type of discharge are only Doppler broadened (25 - 75 mÅ) as a consequence of the low neutral density n_a (10^{18}-10^{19} m^{-3}) and electron density n_e(10^{19}-10^{20} m^{-3}). In most investigations concerning hollow cathode arcs, one temperature for the neutral particles is assumed. The profiles have been recorded by a process computer (PDP 11/20) and have been fitted with a sum of Voigt profiles by means of a non-linear least mean square procedure on a Burroughs 7700 computer. The emitted profiles of ion lines of the plasma could be very well described with one Gaussian (Doppler) profile and temperature T_i (mean residu smaller than 0.5%). On the contrary, it appeared that the emitted profiles of neutral lines could not be described with one Gaussian profile, but needs also either a Lorentzian contribution or an additional Gaussian profile with a larger halfwidth-value as the first one. As Stark and pressure broadening in the neutral line profile are negligible the profile must be made up of two Gaussian profiles with different half value widths, corresponding to the existance of two groups of neutral particles with different temperatures. One group of hot particles has a temperature of $T_{n,hot} = fT_i$ (accuracy 15%), where f depends on the plasma condition and takes values between 0.5 and 1. These hot neutrals are particles which have experienced a charge exchange or elastic collision with the ions. The second group of cold particles has a temperature $T_{n,cold} \lesssim 3000$ K and had no interaction with the ions.
The ratio of hot neutrals and cold neutrals increases with the arc current from appr. 0.3 at 20 A to appr. 1 at 200 A. These experimental values have been compared with values as calculated from the continuity equation of the hot particles under the assumption of thermal expansion. The calculation shows a good agreement in comparison with the measurements.
A distinction between a cold and a hot component for the neutral particles is of importance for the experimental verification of the ion energy balance equation. Moreover our measurements show that $T_{n,hot} < T_i$; this may have consequences for the determination of the ion temperature from charge exchange neutral detection.