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TWO-COORDINATE DOPPLER SPECTROSCOPY FOR THE ANGULAR DIVERGENCE MEASUREMENT OF THE FAST HYDROGEN ATOMIC BEAMS *)

[1]Deichuli P.P., [1]Brul A.V., [1]Deichuli N.P., [2]Kulikova D.A.

[1]*Budker Institute of Nuclear Physics, Novosibirsk, Russia, pdeichuli@inp.nsk.su*
[2]*Novosibirsk State University, Novosibirsk, Russia*

A non–contact method, Doppler spectroscopy, was used to measure the angular divergence of an atomic beam formed in a multi-slit IOS. In an IOS with a slit structure, the angular divergence of the beam has different values in the directions along and across the slits – longitudinal and transverse divergences. To measure both parameters, in principle, it is possible to measure the broadening of the H-alpha (D-alpha) lines in the beam spectrum using observation lines in the axial planes perpendicular and parallel to the slits of the IOS. However, in the real injector circuit, several factors contribute to the broadening of the lines, among which the broadening associated with the angular divergence itself is often not the most significant and difficult to isolate. The angular divergences of the beam can be measured by measuring the profiles of the beam cross section with a set of detectors at various distances from the IOS, however, this is a contact method under extreme thermal loads.

Among the main factors of line broadening are:

a) the spread of the angle between the observation line and the beam lines associated with beam focusing. The range of the spread is determined by the ratio of the IOS aperture and the focal length.

b) the presence of angular divergence of the elementary beams of the IOS due to the finite transverse temperature of the emitter plasma and the influence of inhomogeneities of electric fields due to the multi-aperture structure of the IOS. The spread of the transverse velocities can be characterized by a conditional transverse temperature and its ratio to the acceleration energy eU.

c) the spread of longitudinal velocities associated with the temperature of the emitter plasma and the fluctuations of the accelerating voltage U(t) during the pulse. As shown in [1], when particles with a certain initial spread of longitudinal velocities are accelerated to a high energy, the effect of this spread decreases sharply.

In practice, in the structure of the transverse angular divergence, the contribution from the temperature of the emitter plasma is noticeably less or significantly less than the contribution from the beam formation in the IOS. Since the longitudinal angular divergence is always less than the transverse one and almost does not change when the beam current varies over a wide range, the angular divergence across the slits is interesting and critically important for transporting high-power beams.

The idea of two-coordinate Doppler spectroscopy is to measure the difference in the broadening of the beam fraction lines when they are simultaneously observed in planes oriented parallel and perpendicular to the slits of the IOS. As shown in [1], the resulting line profile under the influence of several factors is described with good accuracy by a Gaussian function with summation of quadratic broadening factors. When measuring the difference factor, the same terms such as temperature, focusing, instability of the accelerating voltage, etc. do not require determination because they cancel each other out, which allows the measurement of the transverse angular divergence factor. This paper presents the results of such measurements for an injector similar to [2].

References

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