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RAPPORTEUR'S REPORT ON SESSION H: LAMBSHIFT-SOURCES

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Session H consisted of three contributions, one on "the Polarization of macromolecules", the other two on Lambshift-sources. This report reverses the time sequence of the contributions.

Very extensive information and contributions on Lambshift-sources together with the covering resummee of T.Clegg can be found in 50 pages of the Vancouver-proceedings [1]. These discussions resulted in a "believe" of a current limitation of these sources for the following facts:

1. The brightness of the 500 eV-H^+-beam cannot be increased significantly.
2. The quenching of the metastable atoms by Cs^+ (macroscopic)fields can only be avoided with perfect space charge compensation.
3. Collisional quenching of metastable atoms in argon is limiting. The third point was excluded from further discussion, because it does not seem to be a limiting factor in practice.

The first fact seems to be an unsurmountable difficulty, because the ion temperature of sources (typically ~ 1 eV) limits the beam divergence to values of $\sqrt{1/500}$=45 mrad, approximately 5 times larger than the beam divergence allowed by the Cs-Ar-geometry. Also ECR-sources with a somewhat larger brightness (compared to duoplasmatrons) have not improved the situation.

An interesting hint in this respect was given by Isoya. He pointed out, that an effect "similar to that in a magnetic bottle" can be used to decrease the transverse phase space. My interpretation is that an adiabatic (collisionsless) passage of ions from a strong magnetic field (in the source) to the low field region at the plasma boundary (from which extraction takes place) can transform transverse into longitudinal motion. The force is due to the field gradient acting on the magnetic moments of the local ion paths.
(As in the magnetic bottle, the longitudinal component is $F_z=\mu\cdot\partial B/\partial z$ where $\mu=I\cdot F$, with $I= e/T=e\cdot\omega/2\pi=e^2\cdot B/2\pi m$, $F=\pi\cdot r^2=\pi\cdot 2mU/e\cdot B^2$. Therefore we get $\mu=eU/B$ and $F_z=eU/B\cdot\partial B/\partial z$, which is well known for mirror fields, similarly F_r prop $-\partial B/\partial r$.)
Therefore ions will increase their longitudinal momentum with a simultaneous decrease of transverse momentum because of div B=0. This(actually old) idea can be an explanation, (i) why ECR sources have a larger brightness, (ii) why duoplasmatron users have worked at the otherwise not optimal "starvation" condition, (iii) why the temperature of the Isoya-source is small (in low current operation) [2], (iv) why -for instance- a maximum B-field in the anode aperture give the highest output [3].

Another interesting statement was given by Isoya, which can give insight in fact Nr. 2. He derived metastable quenching rates from

the assumption of macroscopic space charge compensation outside of a region given by the Debye-length and calculated a 70 % loss of the metastable fraction for his beam geometry and current (3 - 5 μA per hyperfine state). He also proposed improvements based on this understanding, which might lead to a ten-fold current.
The discussions on the Cs^+-limit included the results of Benage[4], who took the presence of resonance frequencies (between 2s- and 2p-states) in the plasma spectrum into account and obtained similar limits as given by Clegg.

The review of Schiemenz stated that the working Lambshift sources are reliable with the ease of fast polarization switching for protons and deuterons (H^- and D^-). Currents of approximately 1 μA per hyperfine state are obtained with polarization degrees, which are somewhat smaller than the ideal values, but the cause of this reduction is understood. Again, the problem of the brightness of the positive beam was discussed as the major limitation. The limiting factors were compared for the working sources and the conclusion was drawn,that "target currents of 2 μA seem possible in the near future".

The question towards pulsing of Lambshift sources (similar to the techniques and improvements achieved in atomic beam sources) was answered negatively, i.e. no intensity increase can be expected from pulsed operation.

The first contribution of session H was on "the polarization of macromolecules". A very difficult technique has been set up during the last year at the reactor Geesthacht in collaboration with DESY in order to investigate proton locations and "sizes" in biomolecules (for instance ribosomes).
Polarized thermal neutrons are scattered from polarized protons in biomolecules. The used solvents were deuterated, such that the polarized target protons can be distinguished by a difference measurement with different neutron spins.
Thermal neutrons were polarized by mirror reflection and a spin flipper could be used to rotate the spin 180°. The $5 \cdot 6 \cdot 20\ mm^3$-target volume was cooled by a $^3He/^4He$-dilution refrigerator and Cr^{5+}-ions served as the "handle" for the dynamic nuclear polarization process employing a 70 GHz-technique.
The preliminary results are encouraging and mark the extension of polarization physics to biophysics.

References

[1] T.B.Clegg, AIP Conference Proceedings No.117, Vancouver (1983), p.63, p.103 and contributions in between

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[3] W.Arnold et al., 5.Int.Polarization Symp., Santa Fe (1980), AIP Conf.Proc. No. 69, p. 882

[4] J.Benage, LANL-report, LA-UR-85-4463