ABS Intensity Studies at SpinLab in Ferrara

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The last 30 years of Atomic Beams

Increase has no concrete explanation!
The last 30 years of Atomic Beams

15x10^{16} atoms/s in PAX proposal as minimum intensity.

More intensity \Rightarrow shorter time for beam polarization \Rightarrow more data
ABS Basics

- Beam formation (dissociator, nozzle and skimmer)
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- Spin selection and focusing with sextupole magnets
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- Beam formation (dissociator, nozzle and skimmer)
- Spin selection and focusing with sextupole magnets
- Hyperfine state population exchange via RF cavities
More goes in but less comes out???

Where does it go?

- Work on adapting dissociator and beam formation to high input flows
- Work on reducing attenuation losses

RHIC
What don’t we know?

- How much rest gas is inside the magnets (RGA losses increase with the RG pressure seen by the beam)
- How to estimate quantitatively the losses to intra-beam scattering (IBS losses increase with beam density and with $\Delta v/v$ of the beam)

Need a combination of simulations and test bench measurements to improve the situation.
SpinLab Program

Work in progress

- **Study** importance of dissociator cooling
- **Tune** scattering cross section in simulation

Future Plans

- **Simulate** and **measure** beam flux through skimmer
- **Simulate** and **measure** intra-beam scattering losses
SpinLab

Unpolarized ABS (CERN)

Movable Diagnostic System (Ferrara)

Polarized ABS (Madison)
Microwave Dissociator Cooling

- Air flow: 20-35 deg C
- Vacuum chamber wall
- Chilled water with antifreeze: -15 to +15 deg C
- Nozzle: 20-300 K
- Collar: 50-150 K

Temperature Sensors:
- Thermocouples
- CLTS
Study of Dissociator Cooling

- WHY? – One difference between RHIC source and others
- What could cooling possibly do?
  - Improve beam thermalization at nozzle ⇒ narrow the velocity spread of the beam ⇒ reduce losses to IBS.
    - Can we work at higher input flows?
    - Can we work with larger nozzles?
  - Reduce recombination of atomic hydrogen before nozzle exit?
  - Increase forward peaking of beam?
Preliminary Results

- Correlation between collar temperature and beam intensity clearly evident but not yet explained. Investigations ongoing!
Tests of DSMC predictions

- Velocity distribution width ($\sigma$ at 50-100K?)
- Beam intensity after 0.8m ($\sigma$ at 200-400 K)
- Beam intensity after skimmer ($\sigma$ at 10-30 K?)

Unpolarized ABS

Diagnostic System
Simulation reproduces the RGA losses in a molecular hydrogen beam for a specific value of the scattering cross section.

100 K nozzle ($T_{eq} \sim 244$ K)
Other nozzle temperatures currently being simulated - $T_{eq} \sim 200-400$ K
Beam Velocity Distribution

- H$_2$ molecular beam and 4mm nozzle at 100K
- Final beam temperature depends on number of collisions during expansion – and thus on both input flow and $\sigma$

T=100 K?
For a molecular H2 beam, 4mm, 100K nozzle:
Simulation predicts that 5.6% of the input flow passes through the skimmer – 1.5 times more than expected for an effusive beam! Additionally, this fraction is essentially independent of input flow and cross section.

VERY preliminary measurement=4.3+/−1.0 %
SpinLab Program

In progress

- **Study** impact of additional dissociator cooling
  - Correlation found with beam intensity, under study
- **Tune** scattering cross section in simulations
  - RGA losses and velocity distributions match for molecular hydrogen beam
    - Extension to atomic beams still to be done
  - IBS losses may need refined model of cross section and different experimental measurements
- More details in talk at **Polarized Sources and Targets 2007**!
SpinLab Program

Future Plans

- Measure beam flux through skimmer (movable CT at skimmer exit)
- Measure intra-beam scattering losses (method developed by Z. Ye at Hermes – talk at SPIN2004).
- Investigate the feasibility of large aperture (2-10 cm) super-conducting magnets and their effectiveness at reducing beam attenuation.
- Design the PAX target for antiproton polarization
Permanent vs Superconducting Magnets

1.5 T poletip
Velocity Distribution

Comparison of measured (Jade Hall) and simulated velocity distributions
- molecular H$_2$ beam
- 100 K nozzle
- 100 sccm input flow

Measured:
- $v_{\text{drift}} = 1274 \pm 8$ m/s
- $T_{\text{beam}} = 19.0 \pm 1.1$ K

Scattering cross section is large for low temperatures!

Simulations underway for SpinLab data