Development of a Polarized $^3$He Ion Source for RHIC

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Overview
- Provide $\sim 10^{12}$/sec 70% polarized $^3$He ions to RHIC
- Pulsed structure: $\sim 1$ second pulse, $\sim 3$ seconds off
- Effective polarized neutron beam
- Allows new, unique high-energy QCD studies
- Allows fundamental tests of the standard model in a future electron-ion collider eRHIC
- Source construction getting underway with goal to carry out test in mid-2012 on EBIS solenoid

Concept for Flow into EBIS
- $P_0 = \sim 1$ torr
- Precision capillary leak, $10^{-6}$ atm-cc/sec
- $10^6$ wall bounces, negligible depolarization

Metastability Exchange Optical Pumping
- Invented in 1963 by Colgrove, Schearer, Walters
- Weak RF discharge excites $^3$He atoms to metastable state
- 10W 1083nm Keopsys fiber pump laser, circularly polarized
- Measure polarization in cell with pump-probe technique
- Output required only $\sim 10^{15}$/sec at 70% polarization

RHIC Electron Beam Ion Source (EBIS)
- 5 Tesla solenoidal field
- Length of ion trap = 1.5 m
- 10 A of 20 keV electrons
- 575 A/cm$^2$ current density
- Output $\sim 10^{12}$ $^3$He$^+$/sec

Magnetic Field Gradients
- Strong gradients in $\sim 0.1$T field outside EBIS pose depolarization threat
- Correction coil: 6,000 A, 25 cm$^2$ (air cooled)
- 45 cm x 50 cm, rectangular
- Relaxation times $\sim 600$ seconds (more than sufficient)

Atomic Processes in EBIS
Processes take place inside EBIS that can lead to depolarization

Charge exchange
$^3$He$^-$ + $^3$He$^-$ + $^3$He + $^3$He$^-$
Only minute effects; $\sigma \sim 10^{-16}$ cm$^2$, approximate rate $10^7$ s$^{-1}$

Recombination
$^3$He$^+$ + $^3$He$^+$ + $^3$He$^+$
which can depolarize. Radiative 3-body process: factor of $\alpha^2$, $\sigma < 10^{-20}$ cm$^2$; negligible

Spin-exchange collisions
$\sigma < 10^{-14}$ cm$^2$: negligible

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