Helium-3 in Planetary Nebulae

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Observe $^3$He using the hyperfine (spin-flip) line of $^3$He$^+$

*Analog of the 21 cm line of H*

$\nu = 8665.65 \text{ MHz}$ \quad $\lambda = 3.36 \text{ cm}$
$^{3}\text{He}^+$

interference

$^{3}\text{He}$

$G93.06+2.8$

$T_{intg}=45.8 \quad R_{gal}=11.8$

$^{171}\eta$
H II Regions
For D highest observed value is a lower limit for cosmological D

For $^3$He lowest observed $^3$He/H is an upper limit for cosmological $^3$He
One is not enough!

Except in cosmology
The PN sample:

Why should I read a slide to you?
PNe He3 at the VLA: Balser, Goss, Bania, Rood (2005)
Some days it’s chicken; some days it’s feathers
He3 in S209 in only 7.5hr!
Conclude reliability level for NGC7009 ~ 0.5 mK
This looks as real as He3 but is much too strong.
GBT Conclusions

• Standing waves are not a problem

• There is still baseline structure (BS) probably resulting from the broadband feed, the polarizer, and or mismatches in the IF system.
  
  ▪ BS varies with frequency sometimes almost invisible other times very problematic
  
  ▪ BS amplitude is proportional to source continuum and moves with sky frequency

• At the mK level there are pseudo-lines

• In some AC bands there are short duration spikes in the ACF at seemingly random times, lags, and amplitudes
Helium-3 Conclusions

• We have found helium-3 in another PN, J320, using the VLA

• We probably have found helium-3 in NGC7009 using the GBT and may have a second detection in NGC6543

• Roughly 25% of PNe meet our selection criteria. To avoid conflict with Monica we should detect 3He in only 1/5

• The scheduling mode and proposal pressure on the GBT may not allow us to solidify these results in the near future.

• The EVLA (10 x more sensitive than the VLA) has great potential
A bonus: He$^{++}$ or O$^{++}$ RRL (a first?)