The 3-Helium Problem

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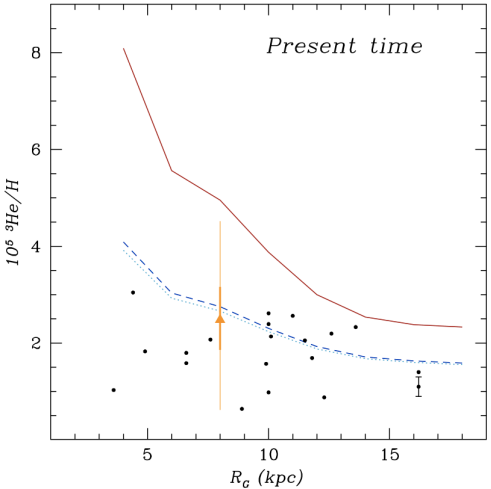
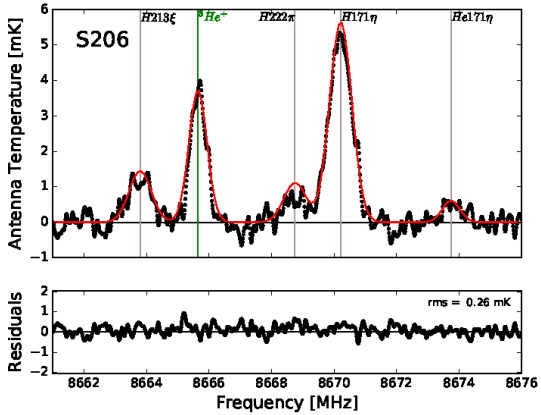
Stellar and Galactic Evolution: 3-Helium Problem

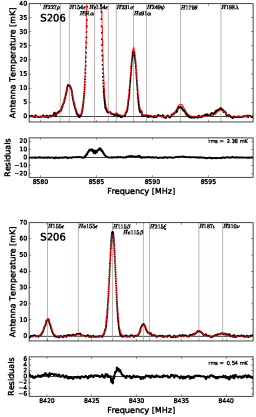


Lagarde et al. (2012); Gloeckler & Geiss (1996); Bania, Rood, & Balser (2002)

GBT Observations: Five H II Regions (G29.9, M16, NGC 7538, S206, S209)

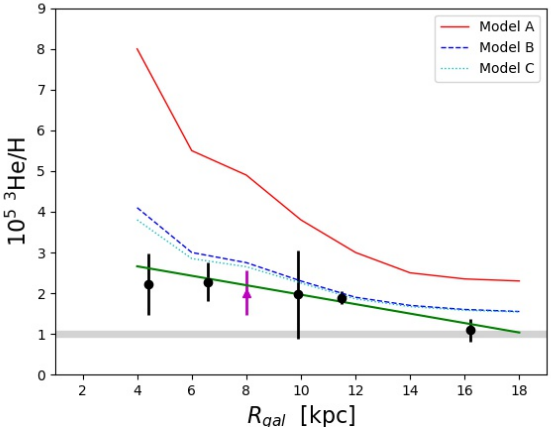


Over 35 RRLs



Balser & Bania (2018)

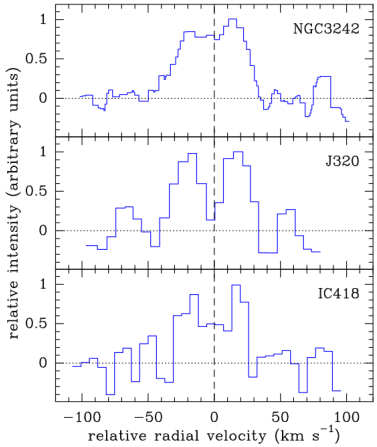
3-Helium Problem Solved?

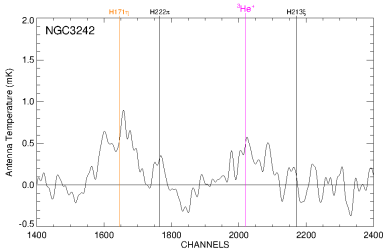


Balser & Bania (2018)

GBT Observations: Four PNe (NGC 3242, NGC 6543, NGC 7009, NGC 6826)

Previous "Detections"





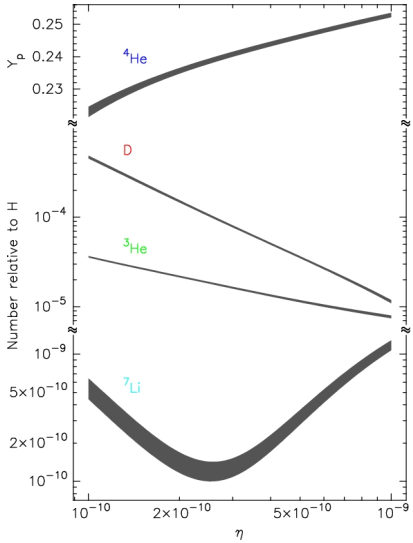
Balser et al. (1997, 2006); Guzman-Ramirez et al. (2016); Balick (priv. comm.)

Summary and Future Work

- Detect $^3\mathrm{He}^+$ in all five H II regions with the GBT.
- $^3\mathrm{He}/\mathrm{H}$ abundances ratios consistent with thermohaline mixing.
- $^3\mathrm{He}^+$ **not** detected in NGC 3242!
- Develop PNe models to derive $^3\mathrm{He}/\mathrm{H}$ (limits).
- $^3\mathrm{He}^+$ PNe observations with the JVLA.

Additional Slides

Primordial Nucleosynthesis



- WMAP:
  $\eta = 6.23 \pm\ 0.17 \times 10^{-10}$
- WMAP + SBBN:
  $\left(^3\mathrm{He}/\mathrm{H}\right)_\mathrm{p} = 1.00 \pm\ 0.07 \times 10^{-5}$

Burles et al. (2001); Cyburt et al. (2008)

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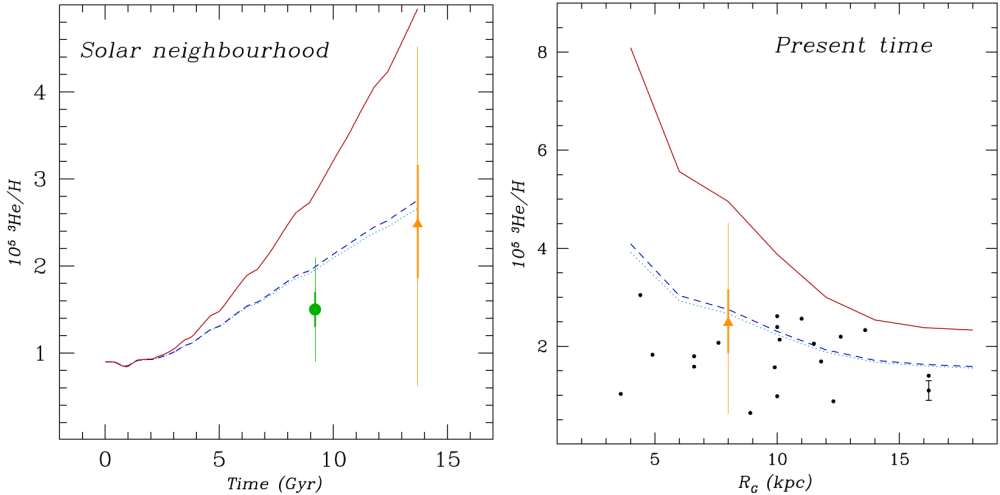
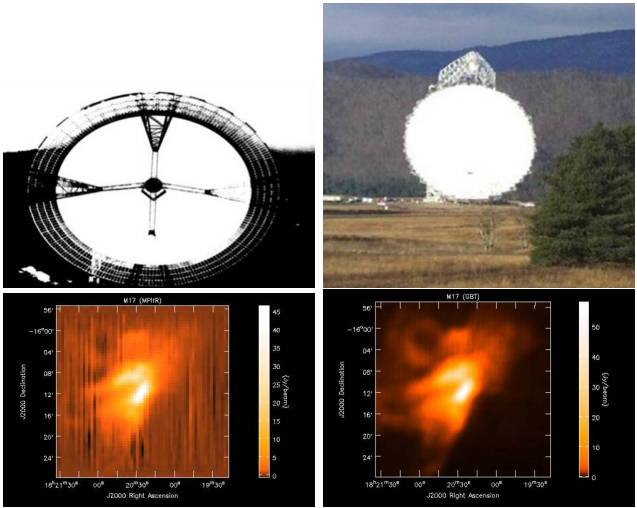


Lagarde et al. (2012); Geiss & Gloeckler (1998); Mahaffy et al. (1998); Gloeckler & Geiss (1996); Bania, Rood, & Balser (2002)

Thermohaline Mixing

$^3\mathrm{He}(^3\mathrm{He}, 2\mathrm{p})^4\mathrm{He}$

MPIfR 100m vs. Green Bank Telescope (GBT)



Balser et al. (1995); Ghigo et al. (Priv. Comm.)

GBT PNe Spectra