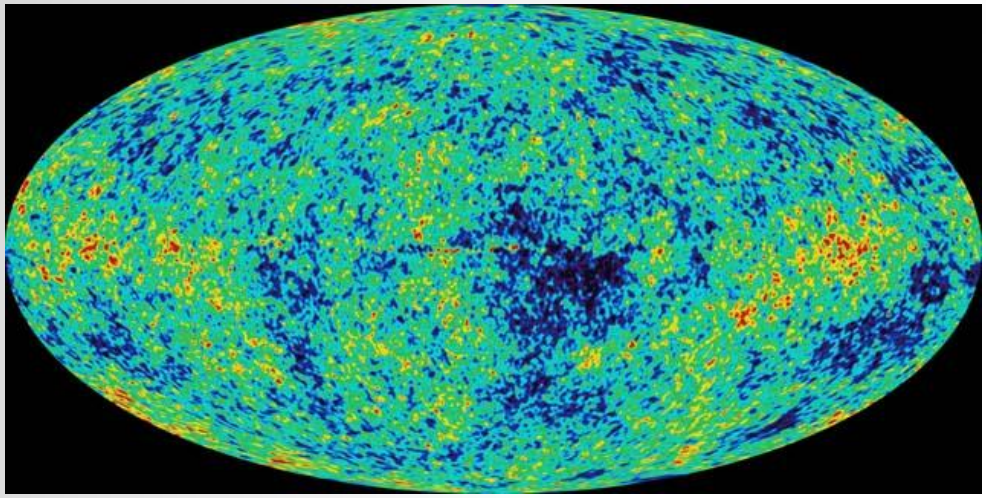
# Looking for Pop III stars with He II line intensity mapping

Eli Visbal (Columbia Prize Postdoc Fellow)
Collaborators: Zoltan Haiman (Columbia), Greg Bryan (Columbia)

# Motivation



NASA/WMAP Science Team

NASA/ESA/HUDF Team

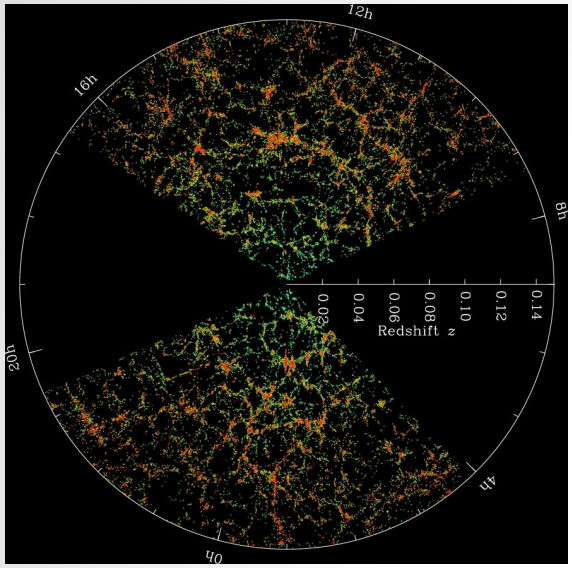
- CMB provides picture at z~1100 and galaxies observed at z<10
- Want to understand transition
- Theoretical predictions for first metal free “Pop III” stars, no observations

# Outline

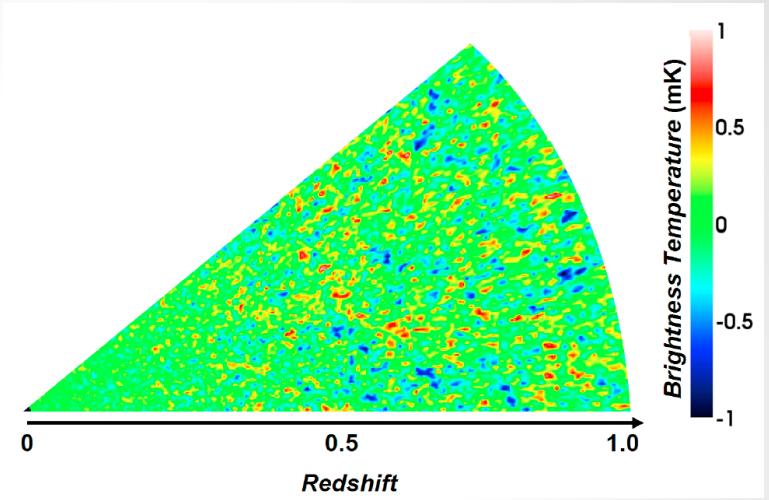
- Intensity mapping
- Pop III stars and He II 1640 Å line
- Pop III signal and possible contaminants
- S/N estimates for hypothetical observations
- Conclusions

# Intensity Mapping

see e.g. Visbal & Loeb 2010, Gong+2011/2012/2013, Lidz+2011, Silva+2013, Yue+2015




(M. Blanton and SDSS)




(Peterson et al. 2009)

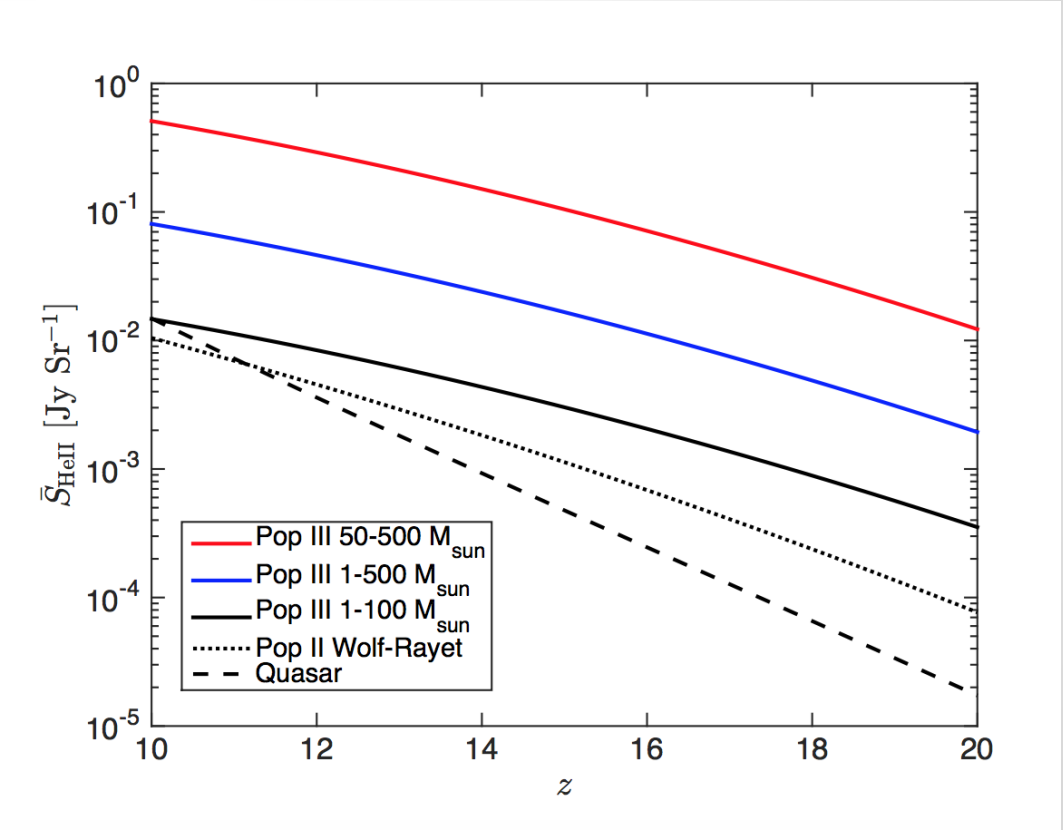
- 3D clustering of galaxy lines without resolving individual sources
- $P(k) = b^2 S^2 P_m(k) + P_{shot}$
- S - total line emission from ***ALL*** sources
- CO, CII, 21cm

# He II 1640 Å line and Pop III stars

- Population III stars - metal free, first stars
- Large masses
- Hard spectra → He II lines
- Most Pop III galaxies too faint to observe directly
- Intensity mapping - total signal from all Pop III
- $P(k) = b^2 S^2 P_m(k) + P_{shot}$
- Combine with other lines such as H$\alpha$
  - $S_{HeII}/S_{H\alpha}$ - hardness of spectrum, IMF
  - $S_{HeII}(z)$ - SFRD as a function of time

# He II 1640 Å Signal and Contaminants

- Focus on Pop III stars in atomic cooling halos
- Assume $f_*$=0.1 of gas forms stars over Hubble time
- Schaerer 2003 line luminosity
- Possible contaminants
  - Quasars
  - Wolf-Rayet stars

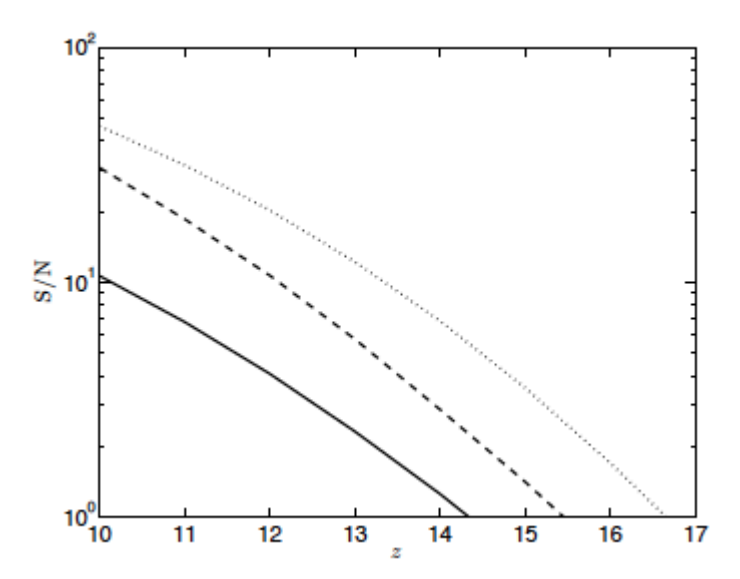


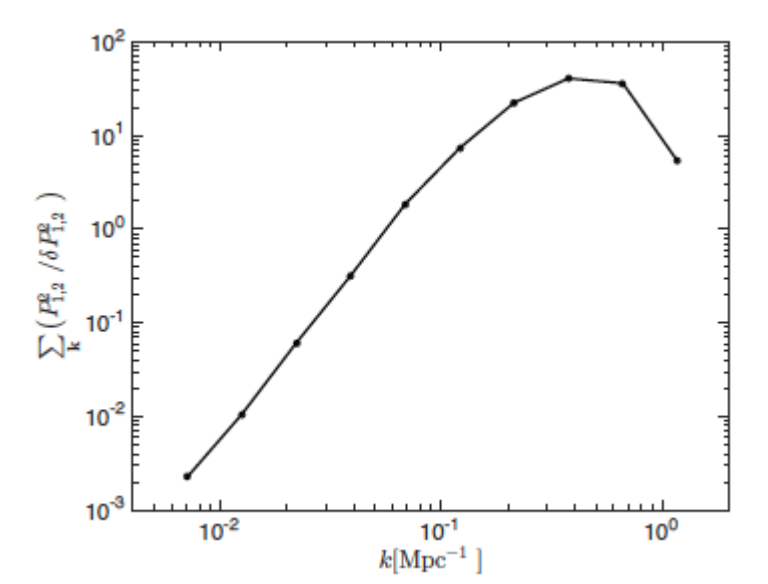
# Hypothetical He II Observations

- Cross correlation
  - Contaminating lines from background/foreground galaxies (e.g. H$\alpha$ at z=1.75 and He II 1640 Å at z=10 both observed at 1.8 micron)
  - Remove with cross correlation
    - CO galaxy emission lines
    - 21cm from IGM
  - Spurious lines contribute to noise
- Space-based instrument
  - 2m dish, background limited (Zodical light, faint stars)
  - 100 simultaneous spectra each 4 arcmin$^2$
  - R = $\nu/\Delta\nu$ = 1000

# He II - CO observation

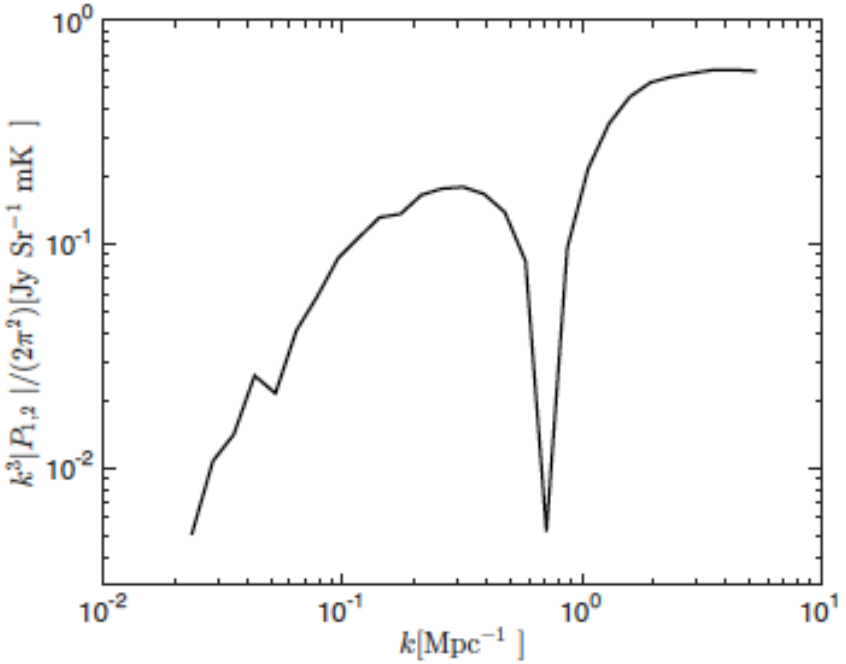
- Cross correlate He II 1640 Å and CO(1-0)
- Assume 2nd generation CO interferometer
  - 10,000 0.4m antennas
  - 1 year integration
- 50-500 $M_{\odot}$ Salpeter IMF, CO normalization from Lidz et al. 2011



# He II - 21cm observation

- Cross correlate He II 1640 and 21cm from IGM (Computed with 21cmFAST, Mesinger et al. 2010)
- Assume 2nd generation 21cm interferometer
  - Murchison Widefield Array scaled up ~40 times
  - 3 year integration
- S/N ~ 20 at z=10



# Conclusions

- Pop III stars in faint galaxies
- Difficult to observe even with JWST
- Intensity mapping can measure total He II line emission from ***ALL*** Pop III stars
- Combine with other lines (e.g. H$\alpha$) to constrain IMF and SFRD(z)
- Possible to achieve high S/N in near future at z~10

For more details see:

Visbal et al. MNRAS Vol 450, 2506 (2015).