Modeling the spectra of the first stars – nebular geometry and predictions for observations

Anna Raiter
European Southern Observatory, Germany (araiter@eso.org)

Robert Fosbury
Space Telescope European Coordinating Facility, Germany (rfosbury@eso.org)

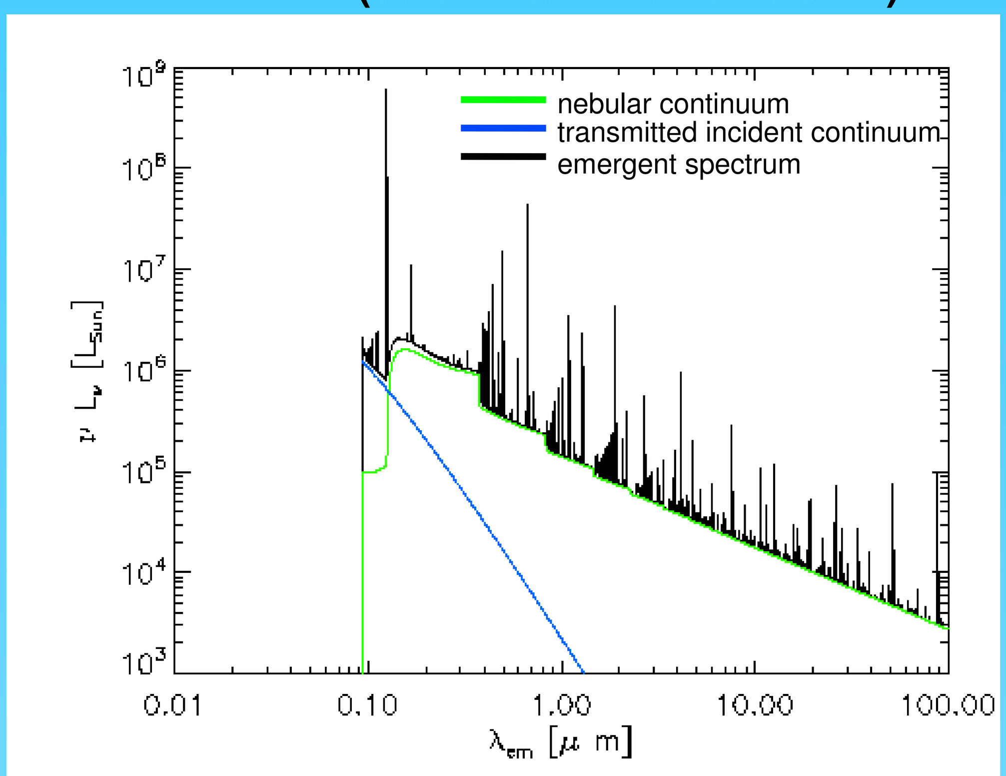
Massimo Stiavelli
Space Telescope Science Institute, US (mstiavel@stsci.edu)

Abstract

Until direct observations of the first stars become possible, we are limited to attempts to predict their spectra and that of their gaseous environment by using photoionization models and theoretical stellar SED. In this poster we present some calculated spectra and consider the particular effects of nebular geometry on the emergent flux. The goal is to find a simple but representative structure to be used in further studies and then predict some observational characteristics of the first stars such as colours. The poster presents the preliminary results.

MODELS

EXAMPLE (calculated with CLOUDY)



Input:

$T_{EFF} = 10^5$ K ($Z_{STAR} = 0$)

logU = -1

$Z_{NEB} = 10^{-3}\ Z_{sun}$

$n_H = 10^2$ /cm³

which gives:

$L_{TOT} = 2\times10^{40}$ erg/s

$L_{>13.6eV} = 1.8\times10^{40}$ erg/s

$L_{NEB} = 6.9\times10^{39}$ erg/s

SIZE OF THE NEBULA

nr of ionizing photons = $V\ n_H^2\ \alpha$

V – volume of the nebula

n_H – total hydrogen number density

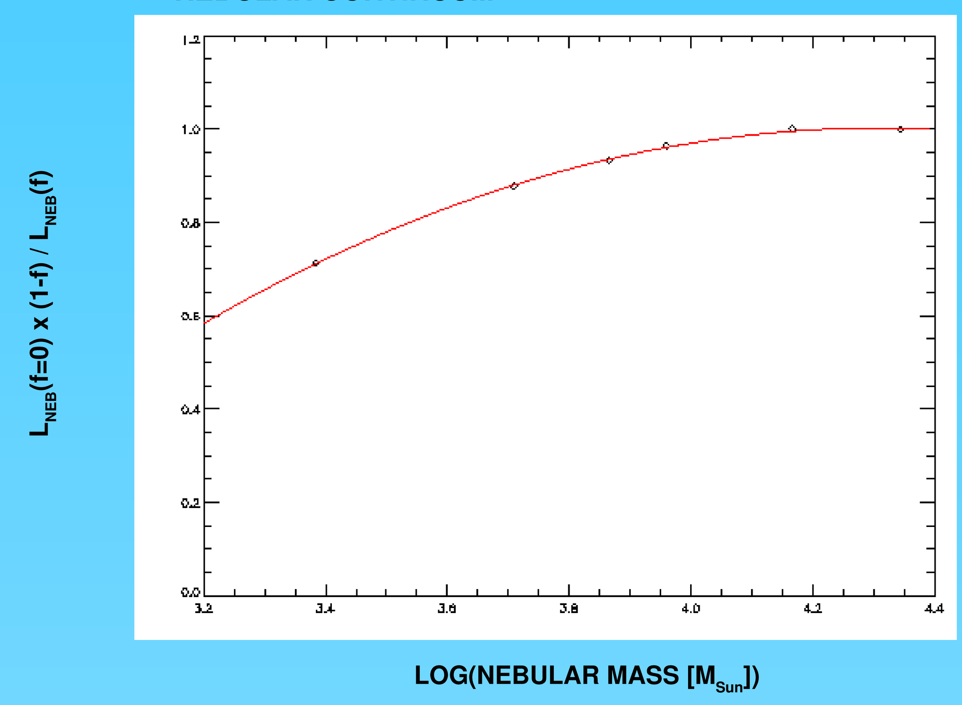
α – recombination coefficient

$n_H \downarrow \Rightarrow V \uparrow$

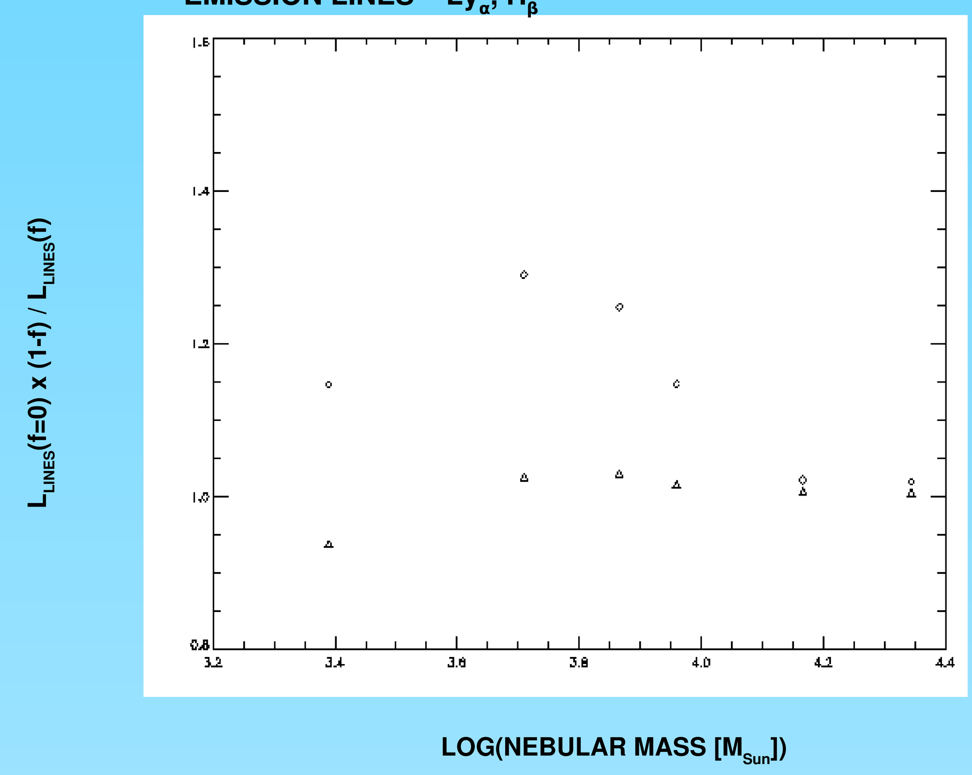
RADIATION VS DENSITY BOUNDED CASE

How the escape fraction (f) changes the luminosity of the nebula and emission lines:

NEBULAR CONTINUUM



EMISSION LINES – Ly_α, H_β



NEBULAR GEOMETRY

ESCAPE FRACTION

Expected values: f = 0.01 – 0.1

COVERING FACTOR

(open vs closed geometry)

- fraction of radiation field which strikes nebular gas
- should be large, otherwise f is too high

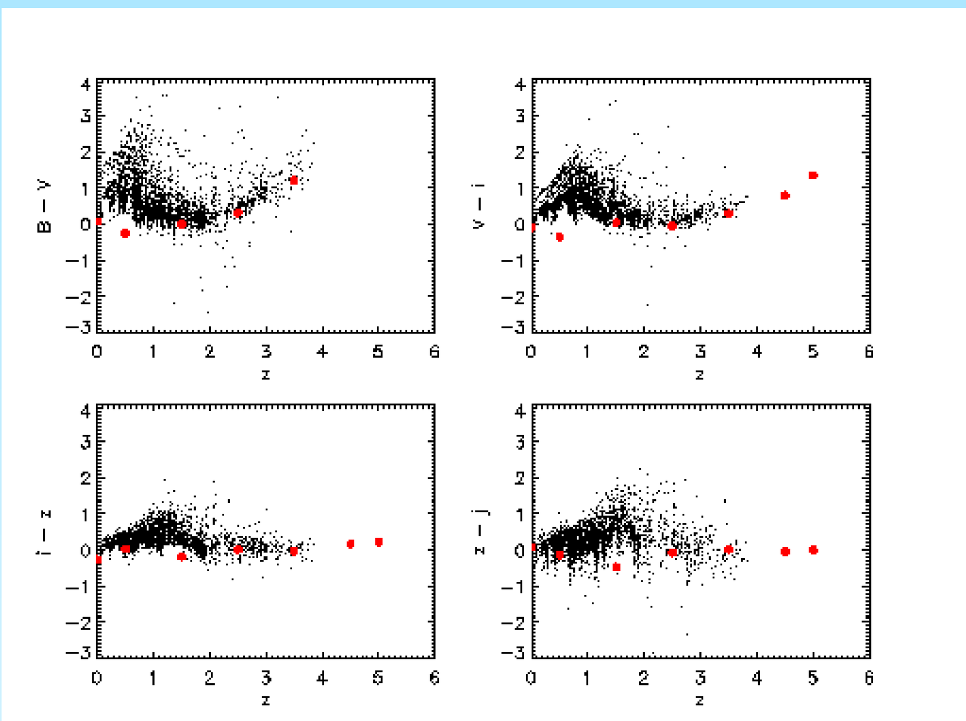
SPHERICAL VS CYLINDRICAL GEOMETRY

- cylindrical geometry (open) results in large escape fraction
- the emergent spectrum is similar to the one calculated for closed spherical geometry with covering factor ~0.5

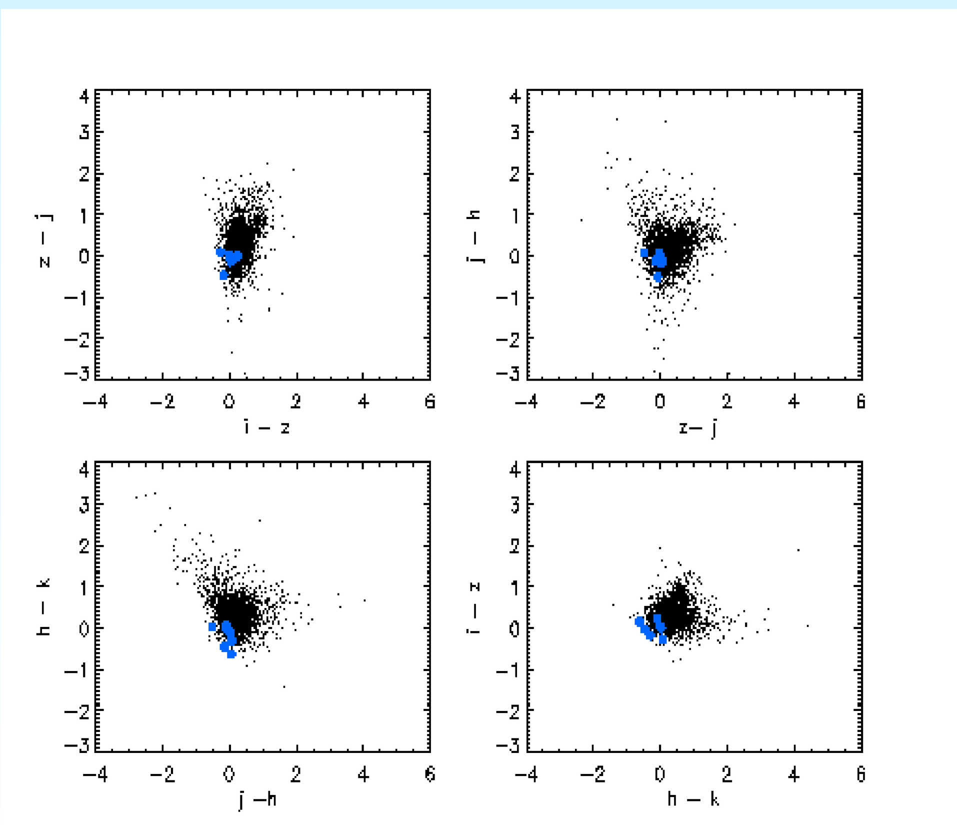
CONCLUSION: spherical geometry with large covering factor, radiation bounded case, to account for density bounded cases (non zero escape fraction) -> the luminosity can be scaled.

WHAT WILL WE OBSERVE ?

colors vs redshift



color – color diagrams



No PopIII star has been observed so far, but......

- **Tornatore et al, 2007 suggested that the PopIII star formation could continue until redshift ~2.**
- **Fosbury et al, 2003 analysed the Lynx arc (z = 3.357) data finding that it could be an extremely low metallicity stellar cluster at high ionization parameter and containing stars with effective temperature ~ 10^5 K.**

To predict what we could observe and to look for thit kind of object in already existing data we calculate the colours and their dependence on redshift. We use the following filters:

- **U VIMOS (3900 Å)**
- **ACS HST: B, V, i, z (F435W, F606W, F775W, F850LP)**
- **ISAAC VLT: J, H, Ks**
- **Spitzer IRAC: 3.6, 4.5, 5.8, 8 µm**

We compare our results with the photometric data collected by GOODS (Great Observatories Origins Deep Survey). Figures show the results (theoretical points have been calculated using the spectrum presented above), the data has been taken from the catalogue of Dahlen & Mobasher.

CONCLUSION

This photometric method could be used for preliminary selection of the interesting objects. However, spectroscopic follow-up is necessary.

WORK IN PROGRESS....