Challenges III:
The Pop III - II Transition

Working Groups:
To foster interaction between theorists and leading high-redshift observers, and to establish simulation roadmaps for the next few years.

Plan of attack:
1. Brief presentation of submitted points
2. Discussion (theory part & observational part)
3. Agree on and write up most important points

Global SF parameters

Ralf Klessen

- How does the IMF of Pop II and Pop III stars **depend on halo parameters**? For example, the degree of turbulence in the halo or its radial angular momentum profile will determine the properties of the disk that forms. Hence they influence its fragmentation properties and the resulting mass spectrum.
- Can dark matter annihilation (if present) heat the inner halo and change the fragmentation behavior of the accretion disk.

Michele Trenti

- What is the **topology of the PopIII/PopII transition**? How different is the region where MW progenitors lived compared to an average region in the Universe?

Masayuki Umemura

- How do the **radiative/dynamic feedbacks** by Pop III work on the transition from Pop III to Pop II ?

About the transition...

Anna Frebel

- **Does a critical metallicity exist**? What sets it (metals, dust)? What is the evolution with redshift/time?
- Understand what the transition trigger actually is
- Understand PopIII.1 & PopIII.2 and what their properties are? What are their mass ranges? What are their environmental impacts?

Simon Glover

- For the metals: is fine structure cooling the only important process, or do CO, H2O, OH etc. play a role?
- How important are **angular momenta/magnetic fields/radiation fields/cosmic rays/ turbulence** on the transition from Pop III to Pop II?

Dan Whalen

- How can we include **dust** in addition to fine-structure cooling in the energy equation in our models of the Pop III/II transition? What role did dust play in the formation of the second stars? Does it allow us to bypass the CMB floor and form truly long-lived stars at z ~ 15 - 20? Do we need to extend our reaction networks beyond H and He to include molecules to get cooling right or can we assume chemical equilibrium for the molecules?

Transition triggers

Someone..

- Was the **transition to low-mass stars extended**, taking place in gas that has been uniformly mixed by metals as now assumed in the numerical models, or prompt, perhaps being driven by the first SNe?

Masayuki Umemura

- **How do dust grains form** after the first enrichment?
- Is the Pop II formation determined solely by the metallicity or is the abundance pattern of Pop III SNe important ?

Global questions

Masayuki Umemura

- How does the metal mixing proceed after Pop III SNe.
- What is the mass range of Pop II? Is it determined by the accretion or fragmentation?
- How important are angular momenta on the transition from Pop III to Pop II? How important are magnetic fields on the transition?
- Are hyper metal poor (HMP) stars Pop II or polluted Pop III.2?
- What is the difference of impacts on the first galaxies between Pop III.2 and Pop II?
- Can we extract any information from high-z GRBs on the transition?
- What is the contribution of Pop III and Pop II to the cosmic reionization?
- Which is more important for seed BHs, Pop III or Pop II remnants?

Bold Question:

Are the current definitions of things sufficient to convey the message(s).

Are they observer/theory friendly?

Theories

for simulation roadmaps

- Dust formation/destruction
  - formation - nucleation, condensation, accretion
  - destruction - sublimation, photodesorption, sputtering, collisions, shattering
  - size distribution

- Pop III – II transition
  - critical metallicity

    metals, dust? evolution with redshift/time? abundance pattern?
  - metal mixing (uniform/inhomogenous?)
  - mass range (minimum mass)
  - rotation (binary formation) /magnetic fields/turbulence/ radiative & kinetic fedbacks by Pop III/cosmic rays
  - dark matter effect (annihilation)

Confront theory with observations

Ralf Klessen

- What is the **binary fraction** of ultra-metal-poor stars? Does it vary with mass/metallicity? Is our sample large enough to tell? (secondary indicators such as binarity are able to separate between different star-formation theories.)
- What are the **observational prospects of finding ultra-metal-poor** low-mass stars or even brown dwarfs? Is that possible? What is the lower mass limit that is likely to show up in future surveys?

Dan Whalen

- If the transition to low-mass stars extended what does this say about the **character of these first polluted stars**? Can we test such models against the new SEGUE samples of EMP stars coming out this summer?

Tim Beers

- **Search Strategies** in next generation exploration for EMP stars Identification of distinctive abundance patters in EMP stars

Anna Frebel

- Use the theoretical results to **predict abundance patterns** of the most metal-poor stars and vice-versa

Summary

Challenges III:
The Pop III - II Transition
Working Group

Big Theory Questions

for simulation roadmaps

- Dust formation/destruction
  - Size distribution/surface area seems most important

  => Develop public dust model (any volunteers?)
- Pop III – II transition
  - Critical metallicity (metals/dust? evolution w/ redshift?)
  - Metal mixing -- what scales are important?

  => Is PopIII star formation possible at high redshift in unmixed patches?
  - Minimun mass range that drives a given population
  - Rotation/B-fields/turbulence/radiative & kinetic feedbacks
- Reducing parameter space
- What the most critical param., how do they drive the outcomes?
- Disprove that there is a Salpeter MF out to z=30??

Big Observational Issues

to connect things to theory

- How to low mass stars really form?
- Binary fraction at low metallicity (+ associated SF processes)

- Search strategies for metal-poor stars in the halo and dwarf galaxies should be (even more) optimized (w/ help of prediction and other empirical results)
- Different classes of metal-poor stars probe the IMF
- Dwarf galaxies are important “lab” to study early star and galaxy formation

- Theorists are encouraged to talk to observers and provide predictions/motivation for current data mining and future observations ;)

Thank You!

"All men have the stars," he answered, "but they are not the same things for different people. For some, who are travelers, the stars are guides. For others they are no more than little lights in the sky. **For others, who are scholars, they are problems**. [..] But all these stars are silent. You --you alone-- will have the stars as no one else has them". [..]

The Little Prince

Acknowledgements:

All the working group participants!

The conference organizers for a great meeting and wonderful hospitality in beautiful Austin!