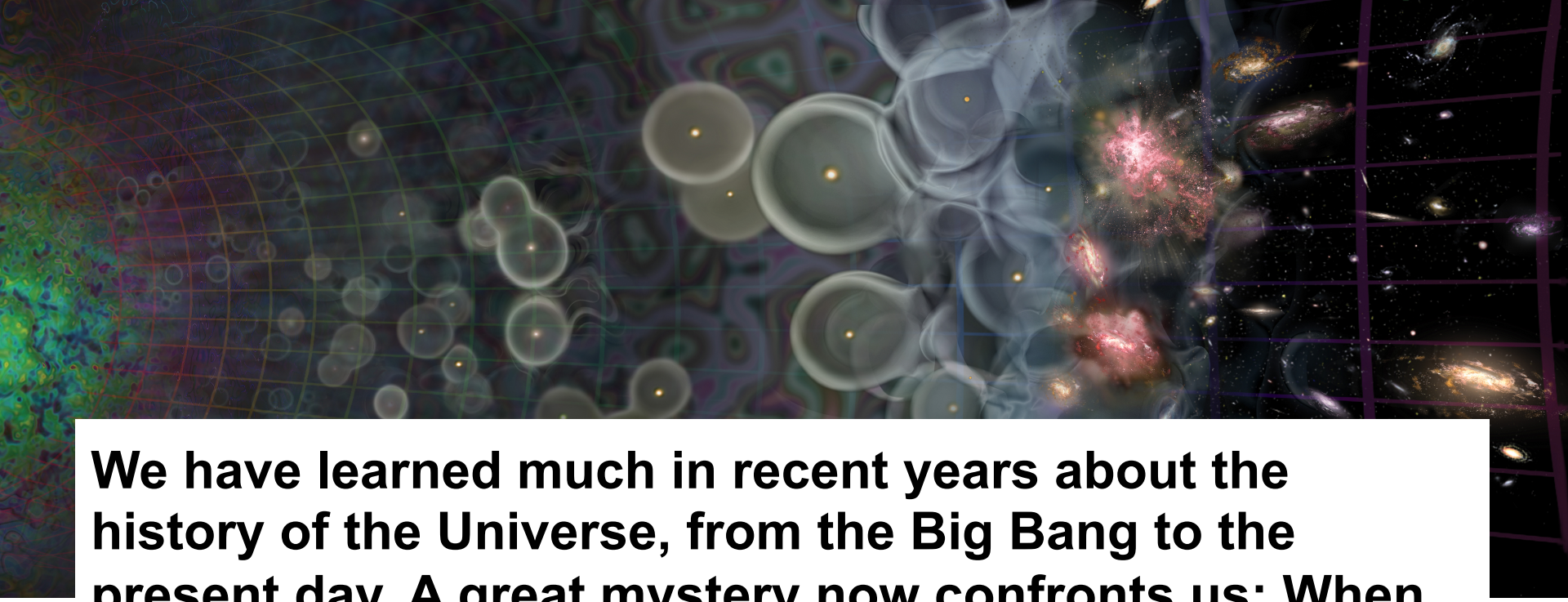
Jet Propulsion Laboratory
California Institute of Technology

Cosmic Dawn Science Interest Group

Joseph Lazio



We have learned much in recent years about the history of the Universe, from the Big Bang to the present day. A great mystery now confronts us: When and how did the first galaxies form out of cold clumps of hydrogen gas and start to shine—when was our "cosmic dawn"?

New Worlds, New Horizons

Image credit: A. Loeb/ Scientific American

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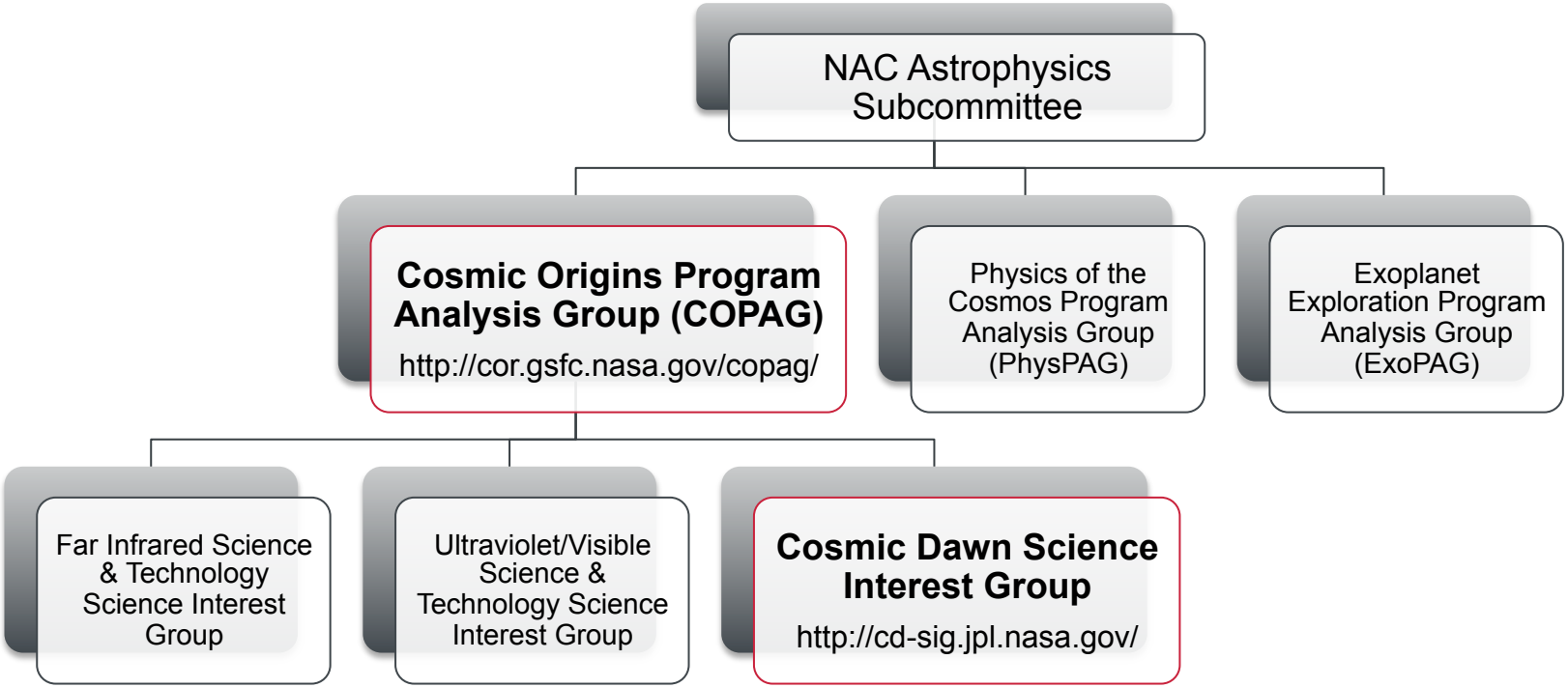


Cosmic Dawn SIG

Charter

- **Collect community input and define long-term Cosmic Dawn science objectives that can be addressed by space-based observations**
- **Identify science cases to provide programmatic focal points that would justify and energize the community to support investment in next generation missions or facilities**
- **Suggest potential technologies for further development, update community-based roadmap for technology development for missions of different scales**

Cosmic Origins Technology Roadmap

http://
cor.gsfc.nasa.gov/docs/
2015CORPATRRev1.pdf

Probe-class Missions

Cosmic Origins Program Analysis Group Call for White Papers : Probe-Class Astrophysics Mission Concepts

To:	The Astronomical Community
From:	The Cosmic Origins (COR) Program Analysis Group Executive Committee
Due Date:	February 15, 2016
Submission:	Submit PDF white papers to COPAG Contact@bigbang.gsfc.nasa.gov

Dear Colleague,

In 2015, Paul Hertz (Director, NASA Astrophysics Division) issued a memo to the astronomical community to stimulate planning for the 2020 Decadal Survey. As part of the subsequent considerations by the COPAG and other groups, the issue of smaller Probe-class missions came up time and time again. Now that the question of Flagship mission studies is advancing to the STDT phase, it is an appropriate time for the COPAG to consider the question of Probe-class missions in a more formal fashion.

Probe-class Missions

Cosmic Dawn

- **Lyα + Hα Emitters from Reionization (viz. SPHEREx)**
- **Gamma-ray Bursts from First Stars (viz. *Fermi*)**
- **Neutral H I from the Intergalactic Medium**
- **[C I] Intensity Mapping**
- **CO Intensity Mapping**
- **…**

Agenda

09:00	Introduction	Joseph Lazio
09:15	Beyond the Horizon: What is Left to Learn After *Hubble* about the First Billion Years?	Steven Finkelstein
09:35	Gamma-Ray Bursts as Explosive Probes of Cosmic Dawn	Valerie Connaughton
09:55	Molecular Gas at Cosmic Dawn	Jacqueline Hodge
10:15	*coffee*	
10:45	The 21cm Reionization Power Spectrum	Aaron Parsons
11:05	Probing the Cosmic Dawn with the *James Webb Space Telescope*	Mia Bovill / Massimo Stiavelli
11:25	Probing Epoch of Reionization Galaxies through Intensity Mapping in the Far-IR	C. M. Bradford

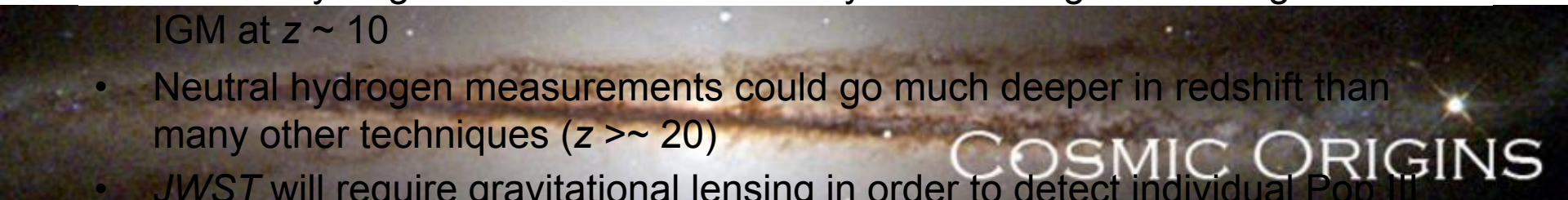
backup

Cosmic Dawn SIG

2016 January 4

Key science questions

- Need to understand UV escape fraction of galaxies, UV luminosity function -> LUVOIR-like telescope but smaller aperture might do escape fraction
- Do Pop III stars produce lGRBs? How would we distinguish Pop III vs. Pop I/II?
- GRB spectra extend to TeV? If so, could use them to probe intergalactic **B** fields
- Want to trace not only star formation during Cosmic Dawn, but also gas that fuels the star formation; not only CO, but dense gas tracers such as HCN, HCO^+
- Could GRBs help understand the escape fraction, or briefly increase the escape fraction of galaxies? (Escape fraction is not constant as a function of time?)
- Neutral hydrogen measurements already constraining the heating of the IGM at $z \sim 10$
- Neutral hydrogen measurements could go much deeper in redshift than many other techniques ($z >\sim 20$)
- *JWST* will require gravitational lensing in order to detect individual Pop III



Cosmic Dawn SIG

2016 January 4

Other comments

- Attendance: ~ 20
- Members of PhysPAG present, nice bridge between PAGs

Probe-class Missions

Cosmic Dawn

- **Lyα + Hα Emitters from Reionization (viz. SPHEREx)**
- **Gamma-ray Bursts from First Stars (viz. *Swift*, *Fermi*)**
- **Neutral H I from the Intergalactic Medium**
- **[C I] Intensity Mapping**
- **CO Intensity Mapping**
- **High Throughput UV Probe (for escape fraction of galaxies)**
- **Mid-/Far-IR Probe for PAHs?**
- **…**