

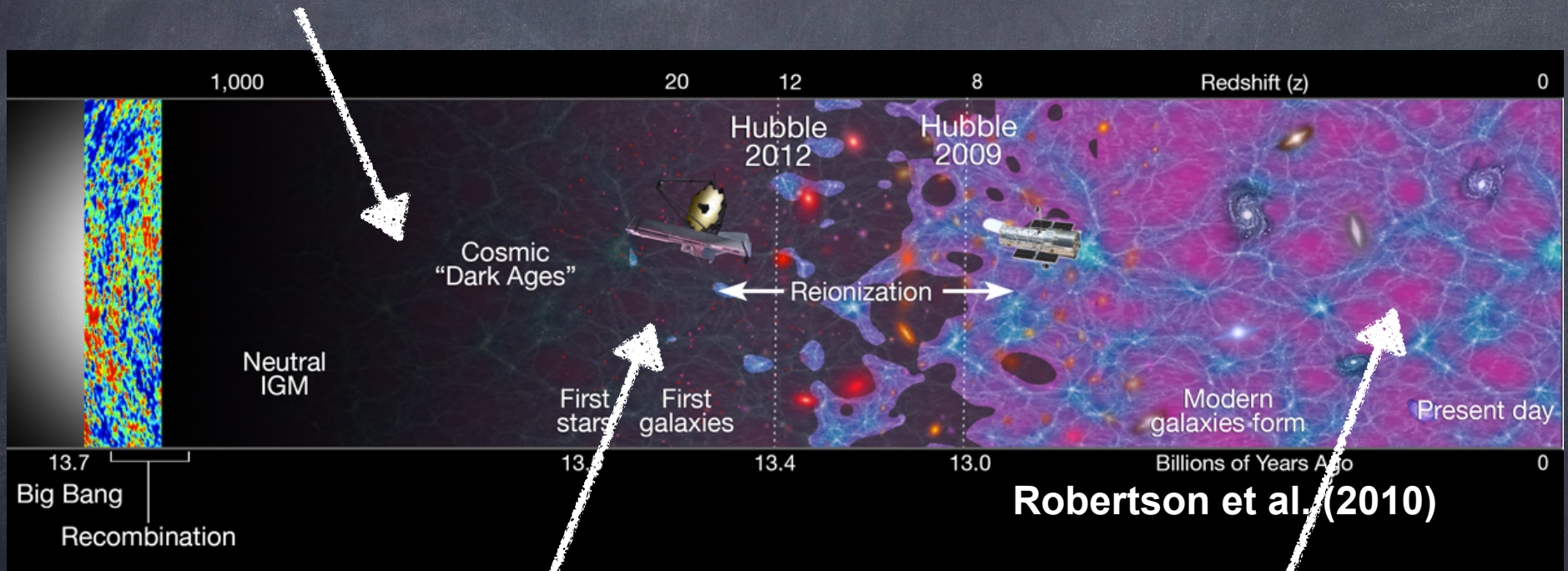
The Global 21-cm Signal, Part I

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The History of the Universe

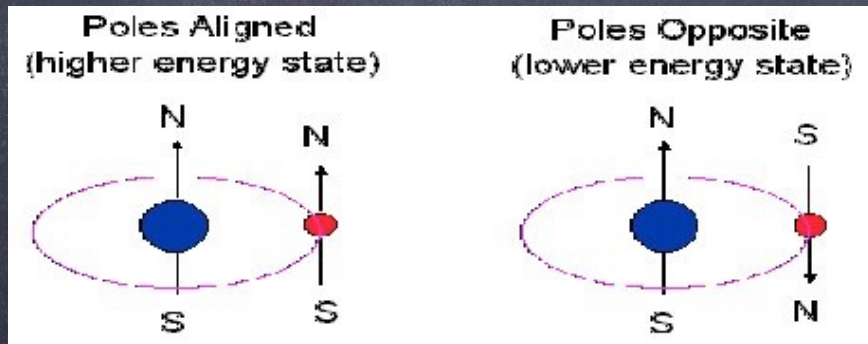
The Dark Ages



Cosmic Dawn

Moon forms
around here!

The 21-cm/Spin-Flip Transition



- Hyperfine transition of neutral hydrogen
- Rest wavelength = 21-cm BUT redshifted by $\sim 10x!$
- Rest frequency = 1420 MHz BUT observed frequencies 20-200 MHz

The Challenges of 21-cm Cosmology

- Terrestrial contamination
- Ionosphere
- Galaxy "foreground"



To the Moon!

- The Moon enables us to explore lower frequencies and obtain a purer signal
 - Use Dark Ages signal to separate exotic physics and astrophysics
 - And study the Cosmic Dawn signal with much cleaner systematics - the crucial step in the interpretation!
- DAPPER/DARE: study global frequency to very low frequencies (early times)
- FARSIDE and lunar arrays: begin to study fluctuations in signal - even richer in astrophysics