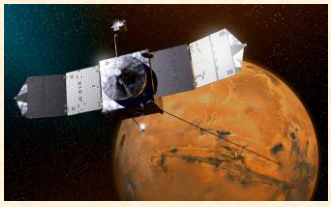
ASTR 1020: Stars & Galaxies

November 18, 2013

- Reading: Chapter 23, Sections 23.3.
- *Mastering Astronomy* Homework on Galaxy Evolution is due Nov. 15th.
- Exam 3 is on Wednesday! Review session Tuesday night at 7 pm in EDUC 155.
- Extra credit telescope observing at SBO. Thursday night at 7 pm.

MAVEN to Mars!



Exam 3 will cover

- All material discussed in class, readings, recitations, and homeworks up through today's class.
- Textbook: Chapters 19, 20, 21, 23.
- *MasteringAstronomy* Homeworks on *The Milky Way*, *Galaxies* and *Galaxy Evolution*.

The Day of the Exam

- Bring a #2 pencil and eraser or pen.
- One sheet of paper with your notes and study hints.
- Bring a calculator if you think you'll need one.
- Please be prepared to get started right away at 1 pm!

Today's Lecture:

The Dark Ages & Cosmic Dawn

- The first stars & galaxies in the Universe.
- The *Dark Ages Radio Explorer* – new space mission led by CU.
- Exploring the Universe from the Farside of the Moon.

Clicker Question

What kind of measurement does not tell us the mass of a cluster of galaxies?

A. Measure velocities of cluster galaxies
B. Measure total mass of cluster's stars
C. Measure temperature of its hot gas
D. Measure distorted images of background galaxies

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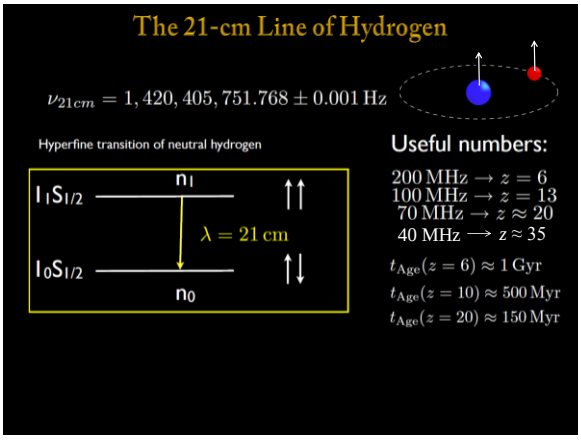
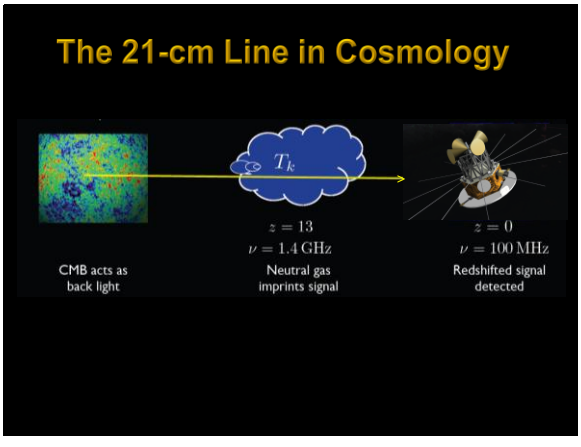
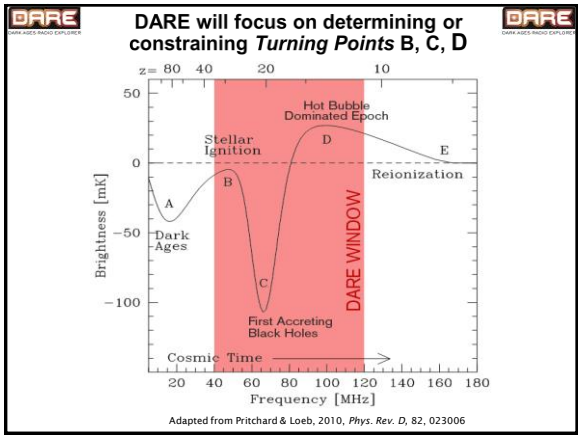
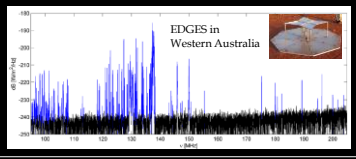


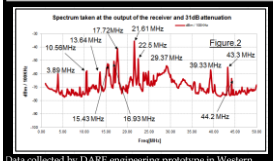




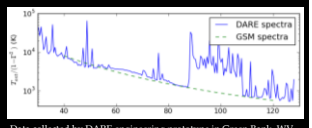
These observations are best done from the lunar farside which is free of Radio Frequency Interference & the Earth's Ionosphere => DARE will be placed in lunar orbit to access the radio-quiet zone above the lunar farside.



Blue spikes in spectrum is caused by interference from the Orbcomm Satellite.

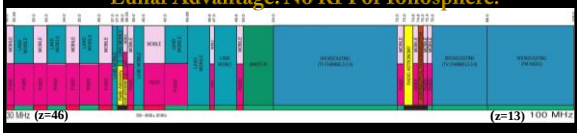


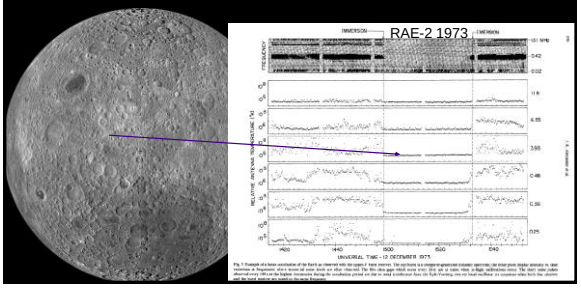
Data collected by DARE engineering prototype in Western Australia. Interference spikes are probably due to naval radar.



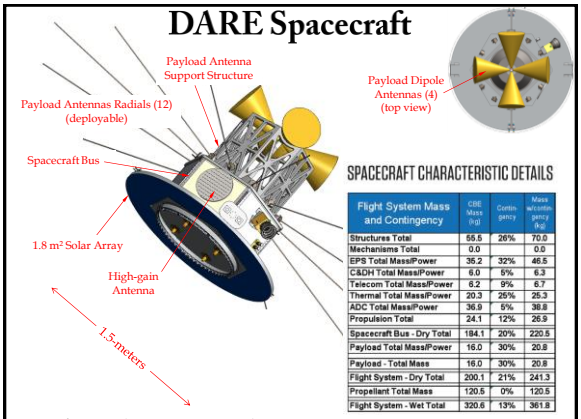
Data collected by DARE engineering prototype in Green Bank, WV. FM band (88-108 MHz) wipes out major portion of low frequency spectrum. Below 60 MHz, effects due to ionosphere become apparent

Lunar Advantage: No RFI or Ionosphere!





DARE Spacecraft

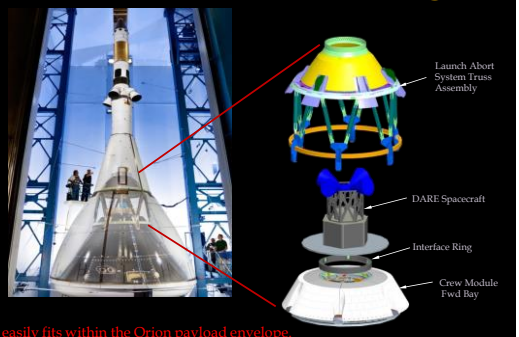


SPACECRAFT CHARACTERISTIC DETAILS

Flight System Mass and Contingency	CBE Mass (kg)	Contingency	Mass w/contingency (kg)
Structures Total	55.5	26%	70.0
Mechanisms Total	0.0		0.0
EPS Total Mass/Power	35.2	32%	46.5
C&DH Total Mass/Power	6.0	5%	6.3
Telecom Total Mass/Power	6.2	9%	6.7
Thermal Total Mass/Power	20.3	25%	25.3
ADC Total Mass/Power	36.9	5%	38.8
Propulsion Total	24.1	12%	26.9
Spacecraft Bus - Dry Total	184.1	20%	220.5
Payload Total Mass/Power	16.0	30%	20.8
Payload - Total Mass	16.0	30%	20.8
Flight System - Dry Total	200.1	21%	241.3
Propellant Total Mass	120.5	0%	120.5
Flight System - Wet Total	320.6	13%	361.8

Burns et al., 2012, *Advances in Space Research*, 49, 433

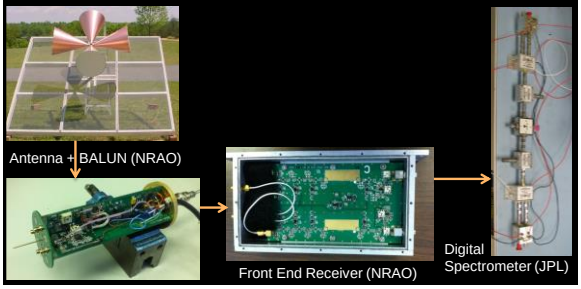
Launch Option: Secondary Payload on EM-1 Orion MPCV Test Flight



DARE easily fits within the Orion payload envelope.

DARE Engineering Prototype: Components

- DARE will operate at low radio frequencies between 40-120 MHz.
- Components: antenna, receiver and spectrometer.
- Instrument Verification Program underway.



1st Generation prototype testing in Green Bank, USA

- 2 weeks in March 2012.
- Initial field tests validated the performance of three stages of DARE instrument: antenna, front-end and digital spectrometer.
- 1st generation prototype testing was successful.
- Initial calibrated spectrum showed effects of Ionosphere, RFI (FM band).

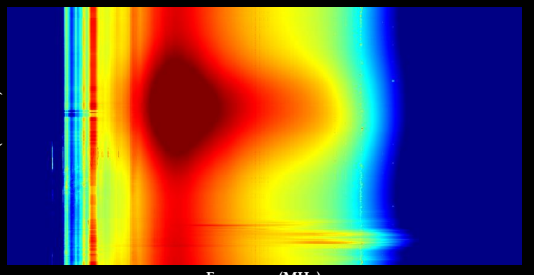
DARE Prototype in Western Australia

DARE Engineering prototype was deployed on March 21, 2012 at Murchison Radio Observatory (MRO).

DARE Instrument Hut

Observations at Western Australia

July 9, 2013



DARE ground based data shows the effect of the Earth's Ionosphere and RFI, the two major challenges of any DARE like experiment (< 100 MHz) from the ground.

Dark Ages Radio Explorer (DARE)

- DARE is designed to address:
  - When did the First Stars ignite?
  - When did the first accreting Black Holes turn on?
  - When did Reionization begin?
- DARE will accomplish this by:
  - Constructing first sky-averaged spectrum of redshifted 21-cm signal at 11<z<35.
  - Flying spacecraft in lunar orbit & collecting data above lunar farside -- only proven radio-quiet zone in inner solar system.
  - Using high heritage spacecraft & technologies/techniques from DARE Engineering prototype.