Top 5 Problems in Modern Astrophysics For the Next 10 Years

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Our Top 5 List:

1. Detection of gravitational waves
2. Population III stars & the epoch of reionization
3. How did galaxies form and evolve?
4. What is the nature of Dark Matter?
1. What is the nature of Dark Energy?

Detection of G. Waves:

- importance:
  - the need to verify General Relativity
  - LIGO (Laser Interferometer Gravitational-Wave Observatory) has never had a confirmed detection
  - probes for astrophysical objects (e.g., can penetrate CMB)
  - predicted waveforms from merging NS, WDs, BHs
- the next 10 years:
  - LISA (2015)
  - LIGO2 (?)
  - if not detected, something wrong w/ GR

Detection of G. Waves:

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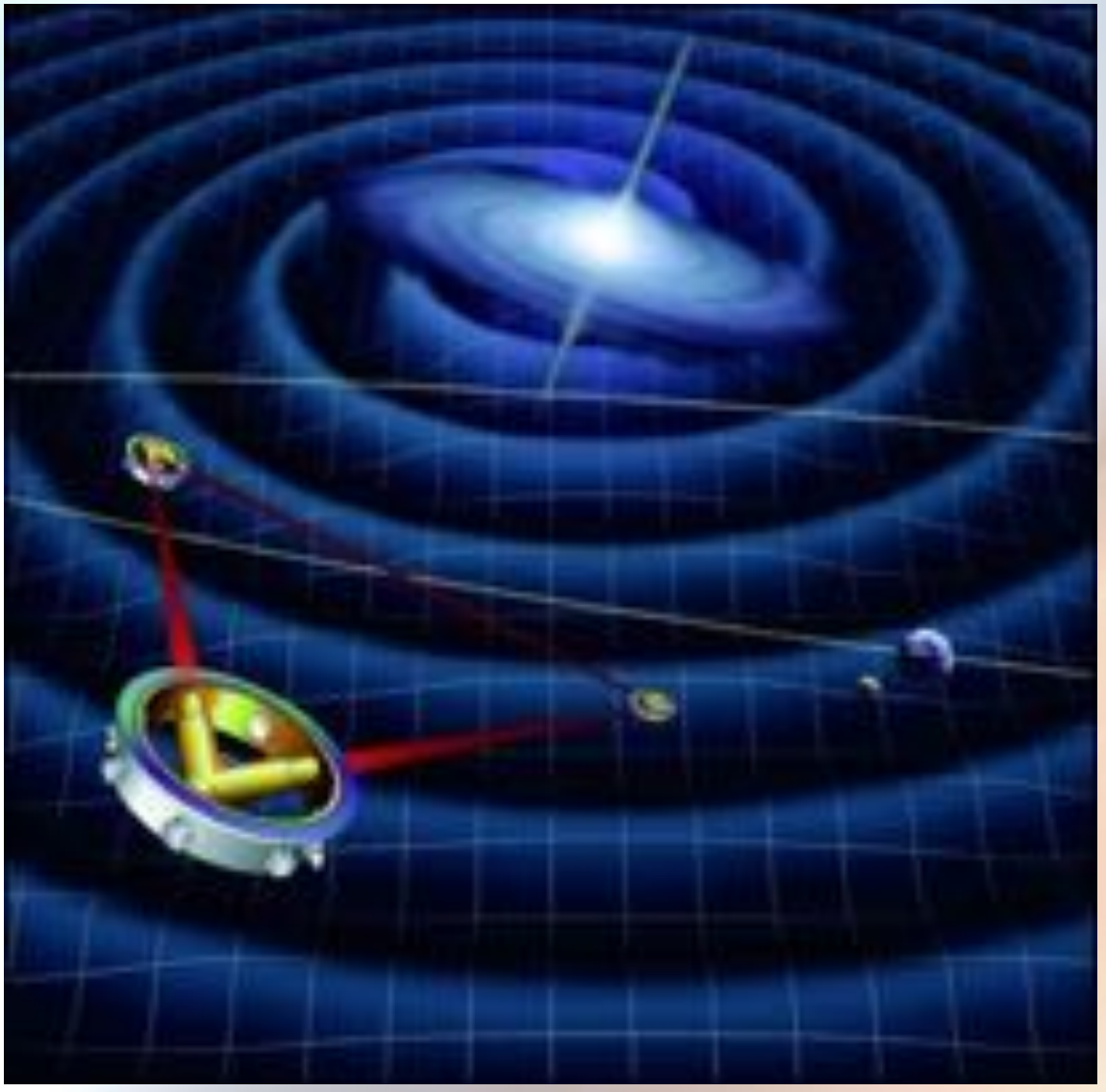


Pop. III Stars & Reionization:

- importance:
  - before Pop. III stars, Universe has only H, He, Li
  - no metals = no CNO cycle, higher Jeans mass
  - Pop. III stars + first quasars produce reionization (affects large-scale structure formation)
  - want more accurate *z* of reionization ($z \sim 11$ from WMAP and $z > 6.4$ from quasars)
  - Pop. III stars never seen directly
- the next 10 years:
  - *JWST*
  - *SWIFT*
  - *PAPER* → indep. observation of reionization at high *z*

How Did Galaxies Form & Evolve:

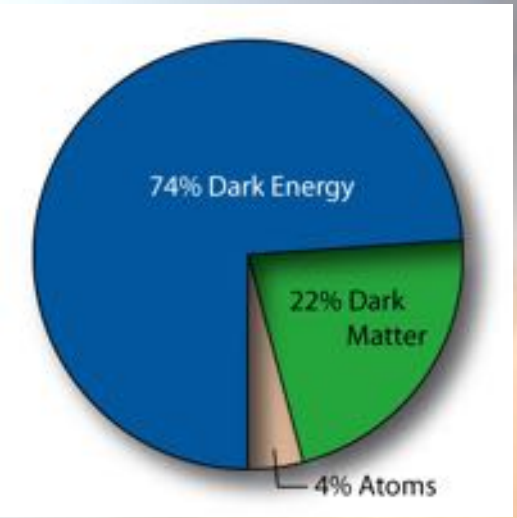
- background:
  - mass estimates of galaxies, morphologies, MFs, LFs, global properties
  - large samples at low *z* (SDSS, 2MASS, DSS, etc.)
  - SMBH at centers of all galaxies? (e.g., role in formation, M-σ relation, effects of environment)
  - hierarchical structure formation
  - simulations overpredict low-L and high-L galaxies
  - at what wavelengths can they first be seen?

How Did Galaxies Form & Evolve:

- the next 10 years:
  - *ALMA* (far-IR, sub-mm) → primordial galaxies!
  - *JWST* (near-IR, mid-IR) → high-*z*
  - large surveys (e.g., SDSS-II, LSST)

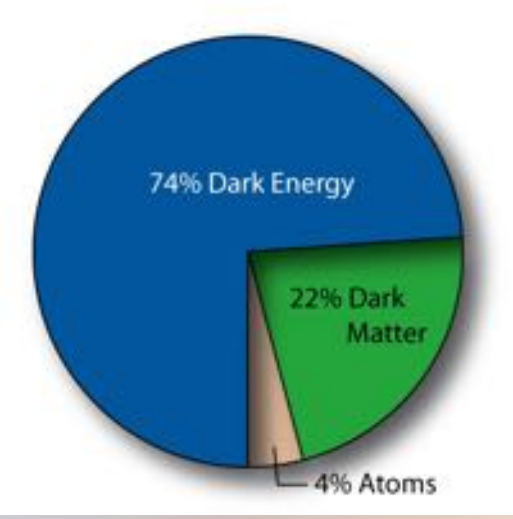
What is the Nature of Dark Matter?

- importance:
  - galactic rotation curves
  - M/L ratios of clusters
  - large-scale structure
- possible explanations:
  - baryonic (e.g., MACHOs, brown dwarfs)
  - non-baryonic (e.g., neutrinos, hot/warm/cold DM)
  - MOND



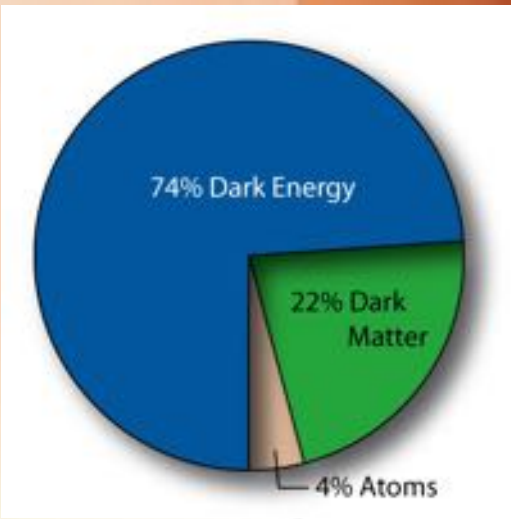
What is the Nature of Dark Matter?

- the next 10 years:
  - LHC
  - ILC
  - ArDM



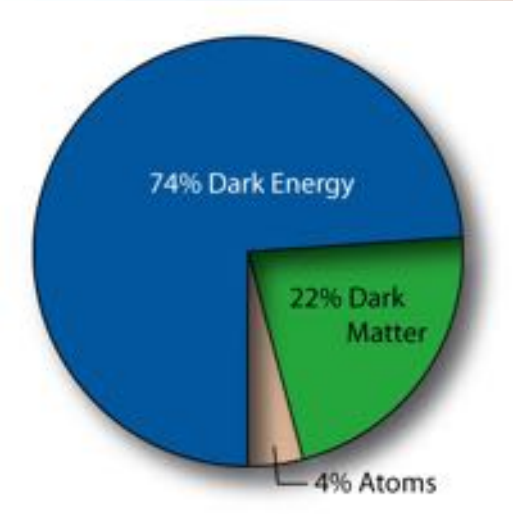
What is the Nature of Dark Energy?

- importance:
  - accelerating expansion from high-*z* Ia SNe
  - WMAP cosmology – how much DE there has to be to make Universe flat ($\rho = \rho_{crit}$)
  - large discrepancy between theory of vacuum energy density vs. observation (10^{120}!)
- explanations:
  - cosmological constant
  - quintessence
  - modified laws of gravity



What is the Nature of Dark Energy?

- the next 10 years:
  - want to distinguish different models
  - determine EOS parameter (*w*)
  - ground-based surveys: SDSS II, LSST, SNLS



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Other Problems:

1. Where are the missing baryons?
2. What causes GRBs?
3. How can we explain UHECRs above the GZK cutoff?
4. How do high mass stars form?
5. How can we detect extrasolar terrestial planets?

Discussion