

# VIEWS OF THE UNIVERSE: PAST AND PRESENT

George Ellis

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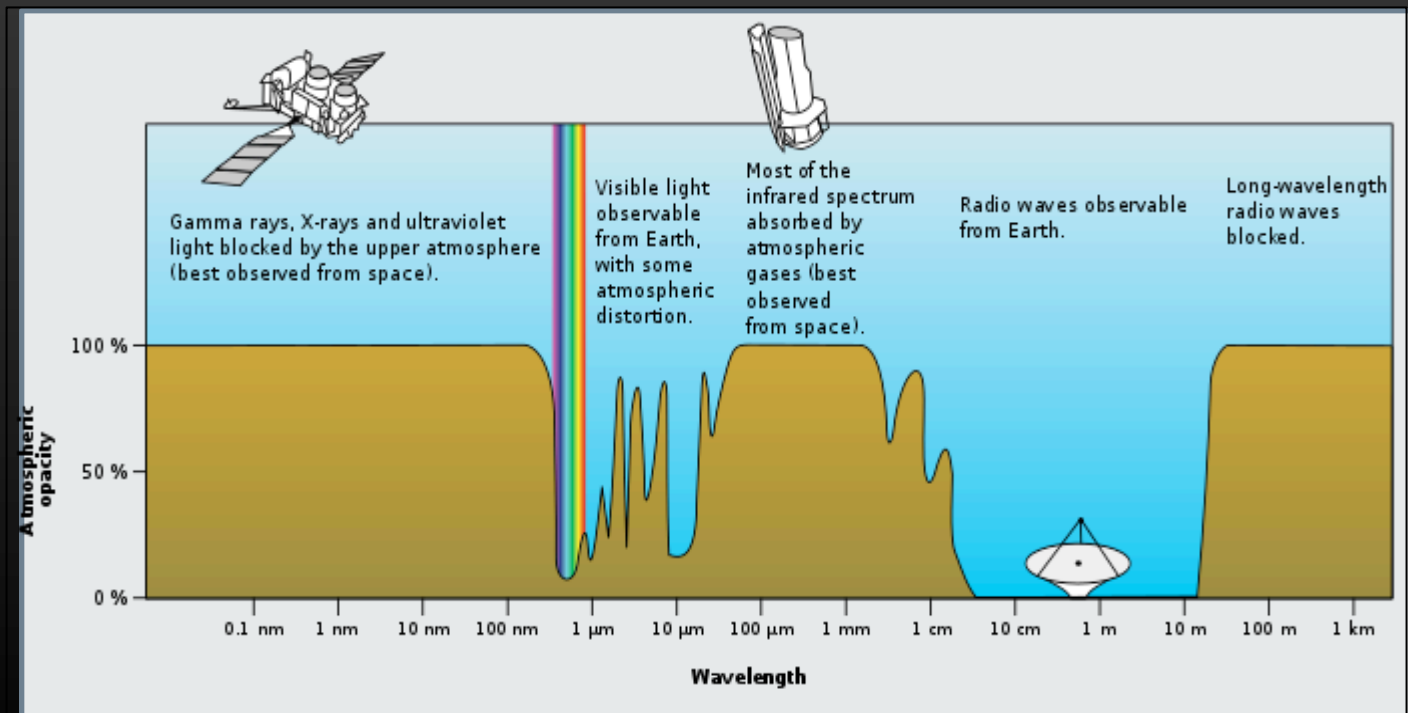
*Feast Fest 2017:  
Trends in Astronomy*

# COSMOLOGY THEN (1961)

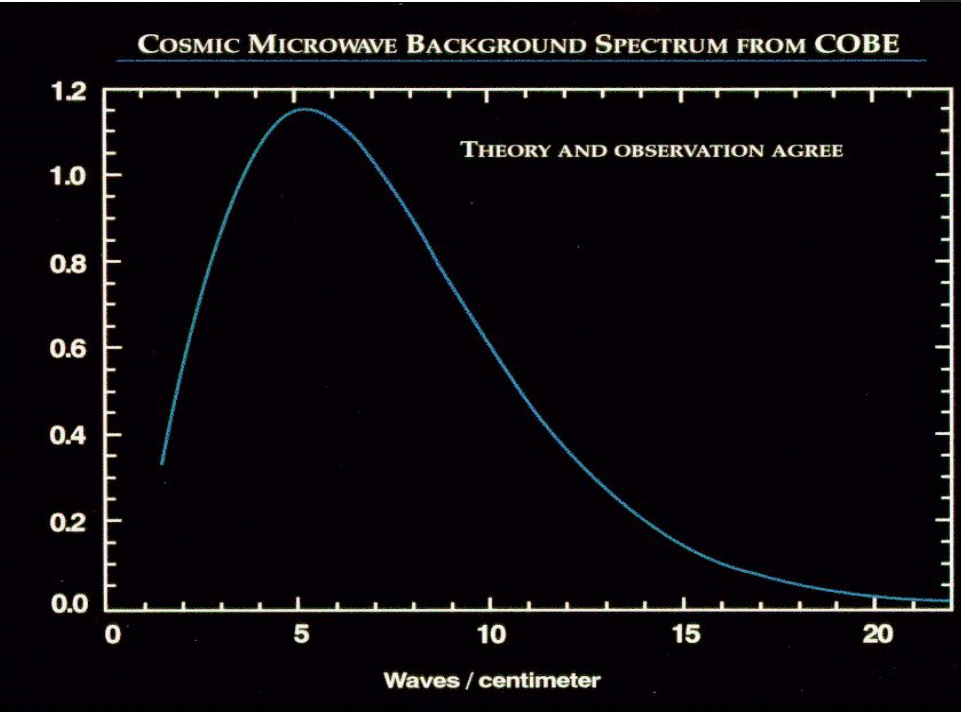
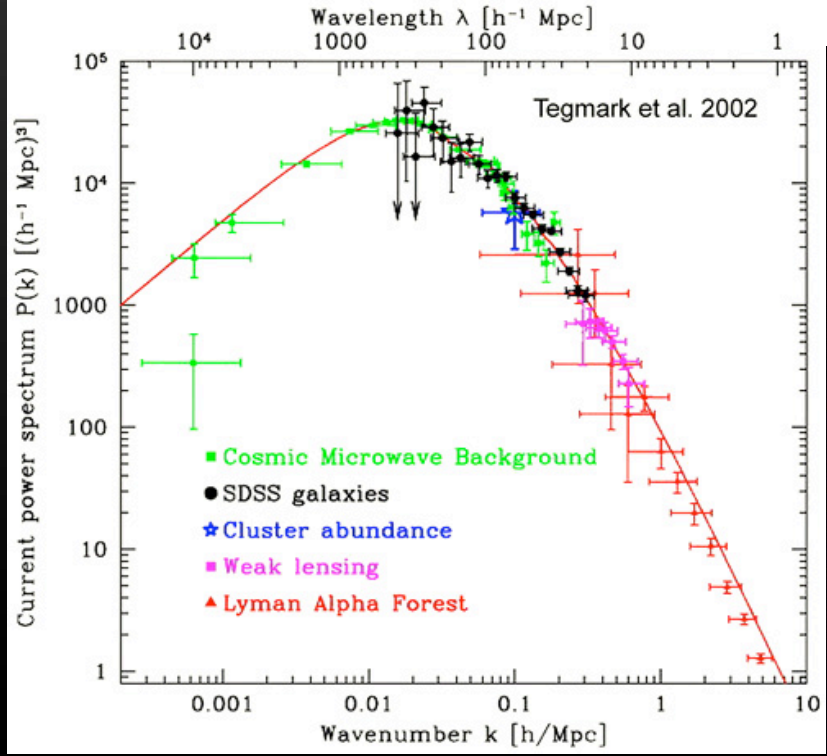
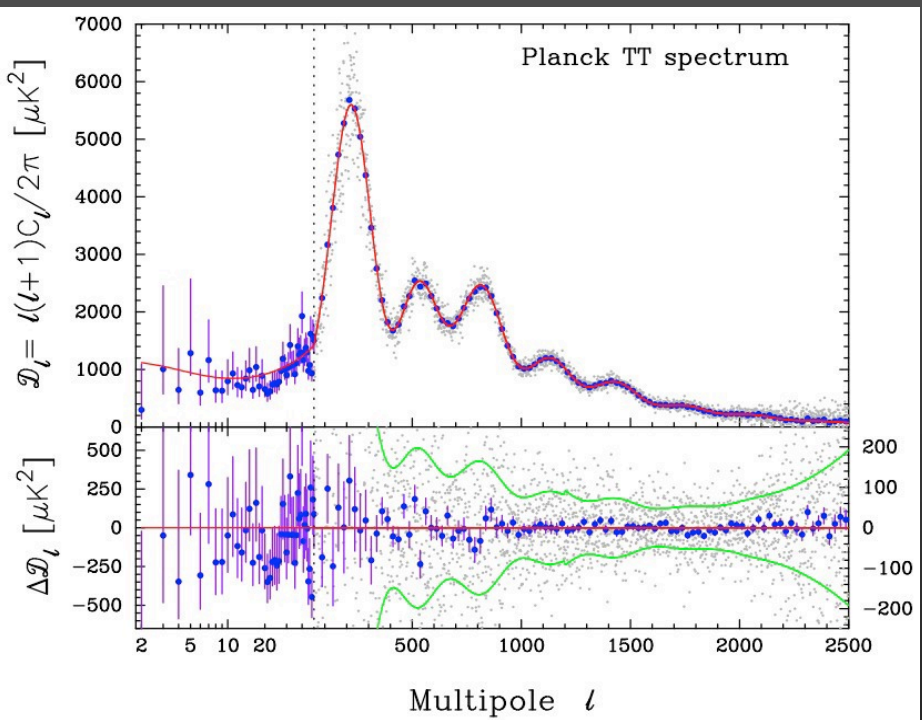
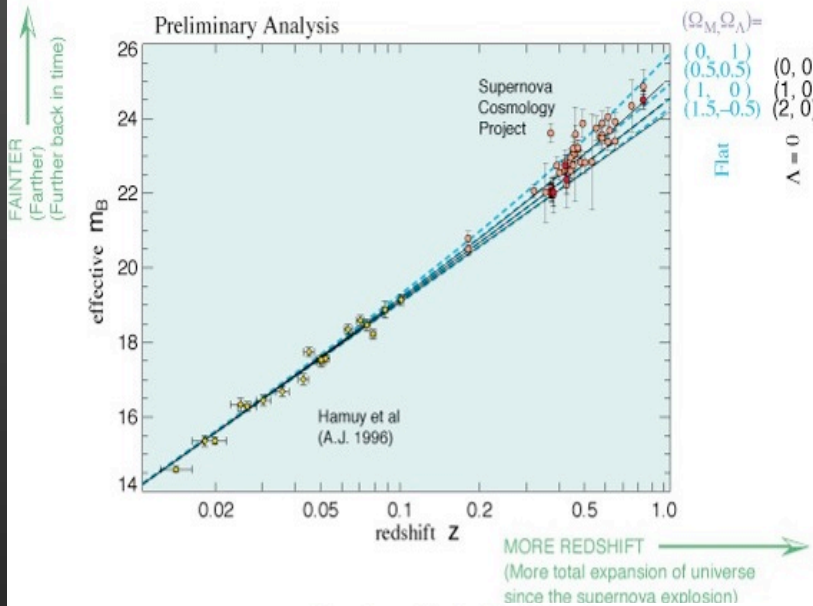
- Optical: Mount Palomar 200" Hale telescope, Largest redshift: 0.42 (Baum)
- Radio sources and source counts: 76-meter Lovell Telescope at Jodrell Bank Observatory,  
Cambridge Interferometer
- Cosmology: "just two numbers" (Sandage):  $H_0$ ,  $q_0$ 
  - N.B. included cosmological constant
- Hubble trouble: age of the universe
- Horizons just clarified (Rindler)
- FLRW taken for granted
- ? Start to the universe? Predictions due to symmetry?
- Regarded as philosophy by hard core physicists

# COSMOLOGY NOW (2019)


- New generation ground telescopes, e.g. SALT, ACT, BICEP
- Interferometers and VLBI, e.g. EVN, VLBA, ALMA, SKA
- Space telescopes, e.g. Hubble, Highest redshift 11.09. COBE, WMAP, Planck.




# Hubble Plots



# COSMOLOGY NOW (2019)

- Hot Big Bang and CMB spectrum (why was this missed by Tolman 1934?)
  - Nucleosynthesis (Gamow first)
  - Inflation
  - CMB anisotropies and structure formation, BAO
  
  - QSOs and black holes
  - Gravitational lensing
  - Dark matter
  - Dark energy
  
  - ? Start to the universe? – Penrose, Hawking, energy conditions
  - ? Alternative topologies?
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# COSMOLOGY AND PHYSICS

- Gravity                                      Apple, moon, cosmos                                      ✓
  - Atomic physics, QM                                      Decoupling, CMB                                      ✓
  - Nuclear physics                                      Nucleosynthesis                                      ✓?
  - Particle physics                                      Inflation                                      ??? – only if Higgs
  - Quantum Gravity                                      Start to universe                                      ?????
  - Playground for hard core physicists
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# COSMOLOGY NOW: ISSUES

- Hubble trouble
  - Cusp-Core, dark halos
  
  - Inflaton?? – Higgs??
  - Dark matter?? - experimental tests
  - Dark Energy/Cosmological constant ?? – problems if  $w < -1$ .
  
  - Consistency tests:
    - Copernican principle
    - Matter dipole same as CMB dipole
    - High  $z$  element abundances
    - Age of the universe  $>$  age of stars!
  
  - Multiverse???
  - Limits of observations and of physics tests
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# WHAT DID NOT HAPPEN

- Steady state universe
  - Bianchi models (spatially homogeneous, anisotropic)
  - Inhomogeneous cosmology
  - Small universes (circles in the CMB sky)
  - Varying speed of light cosmologies
  - Alternative gravity
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# COMING

- This document presents a Strategic Vision for the Gemini Observatory, focusing on its role beyond 2021. At this time the infrared-optimized James Webb Space Telescope (JWST) will have been gathering data for over two years, the Large Synoptic Survey Telescope (LSST) will be near the end of its science commissioning phase and will soon be embarking on its ten-year all-sky survey. Construction of the Giant Magellan Telescope (GMT), the Thirty Meter Telescope (TMT), and the European Extremely Large Telescope (E-ELT) will be well underway, hearkening in a transition from the present '8m era' into one where the dominant ground-based telescopes will be 30m-class facilities.

# MICHAEL FEAST: PAPERS 1951 – 2017 (APJ)

- The Cepheid period-luminosity zero-point from Hipparcos trigonometrical parallaxes
- M Feast, RM Catchpole
- Monthly Notices of the Royal Astronomical Society 286 (1), L1-L5 (1997)
  
- A period–luminosity–colour relation for Mira variables
- MW Feast, IS Glass, PA Whitelock, RM Catchpole
- Monthly Notices of the Royal Astronomical Society 241 (3), 375-392 (1989)
  
- Cepheids as distance indicators
- MW Feast, AR Walker
- Annual review of astronomy and astrophysics 25 (1), 345-375 (1987)
  
- The brightest stars in the Magellanic Clouds
- MW Feast, AD Thackeray, AJ Wesselink
- Monthly Notices of the Royal Astronomical Society 121 (4), 337-385 (1960)

**Key issue: the distance scale!**

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