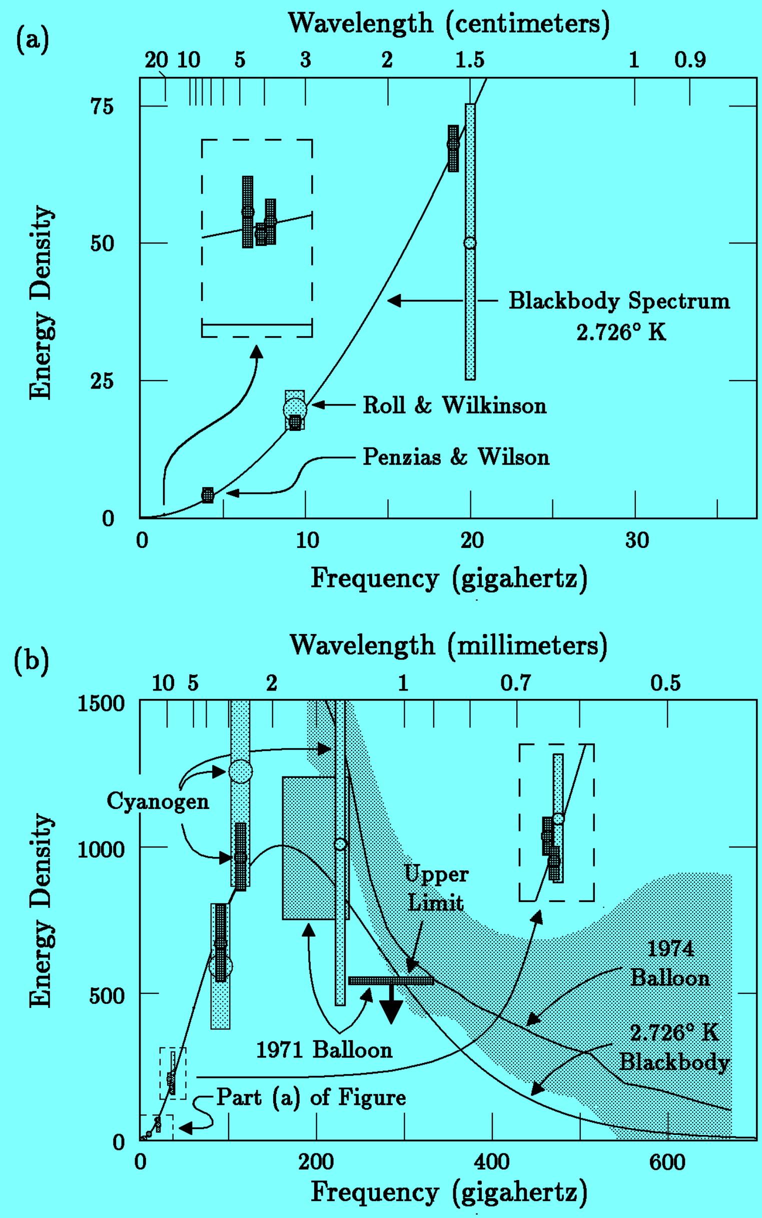
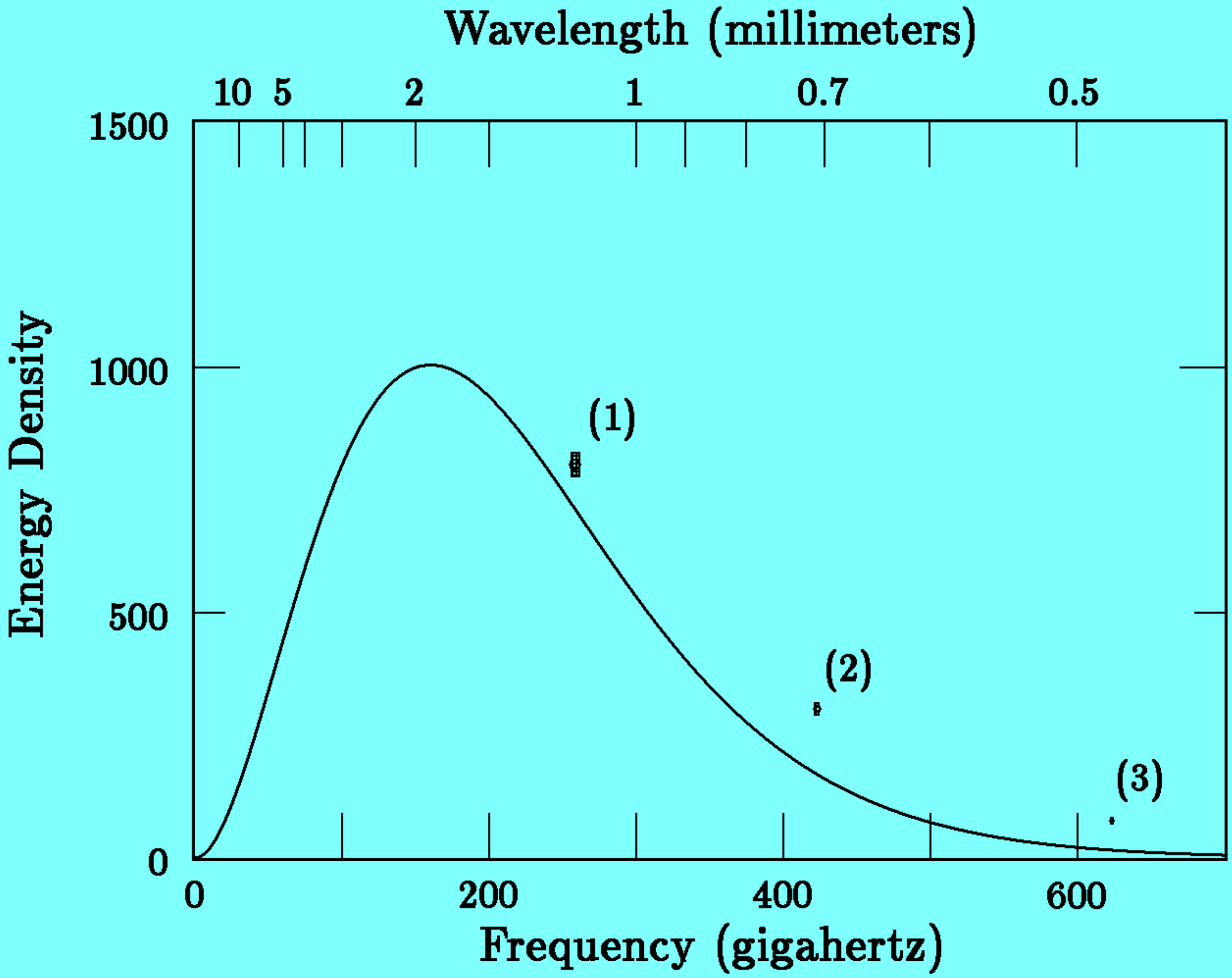
8.286 Lecture 19
November 19, 2013

THE COSMOLOGICAL CONSTANT



CMB Data in 1975



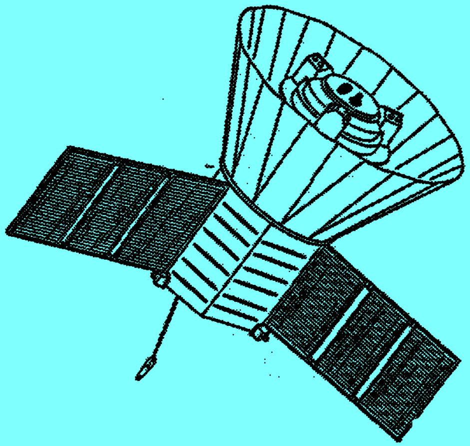
Data from Berkeley-Nagoya Rocket Flight, 1987

Preprint No. 90–01

COBE PREPRINT

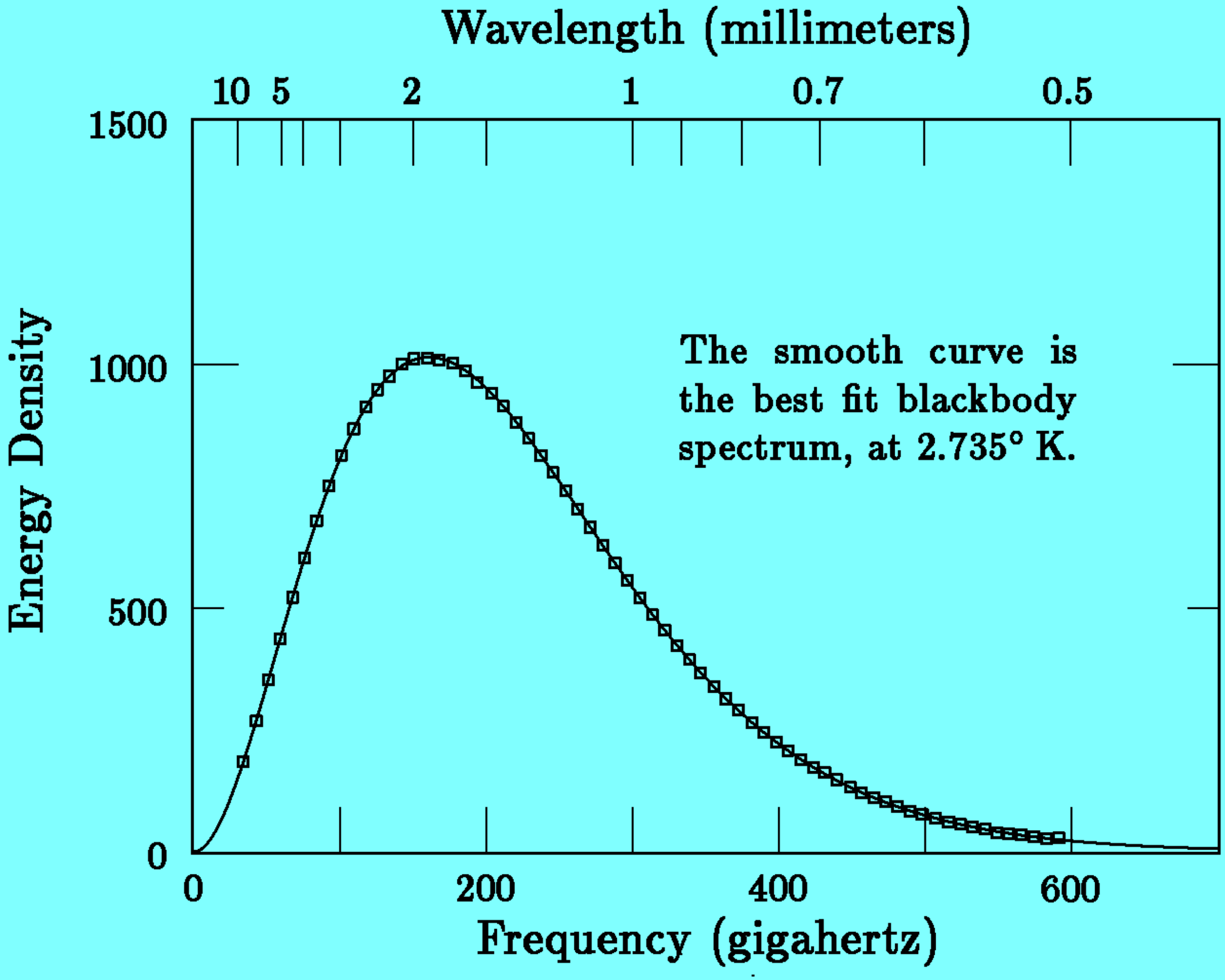
A PRELIMINARY MEASUREMENT OF THE COSMIC MICROWAVE BACKGROUND SPECTRUM BY THE COSMIC BACKGROUND EXPLORER (COBE) SATELLITE

J.C. Mather, E. S. Cheng, R. E. Eplee, R. B. Isaacman, S. S. Meyer, R. A. Shafer, R. Weiss, E. L. Wright, C. L. Bennett, N. W. Boggess, E. Dwek, S. Gulkis, M. G. Hauser, M. Janssen, T. Kelsall, P. M. Lubin, S. H. Moseley, Jr., T. L. Murdock, R. F. Silverberg, G. F. Smoot, and D. T. Wilkinson.



COSMIC BACKGROUND EXPLORER

Cover Page of Original Preprint of the COBE Measurement of the CMB Spectrum, 1990



Original COBE Measurement of the CMB Spectrum, Jan 1990. Energy density is in units of electron volts per cubic meter per gigahertz.

Summary of Lecture 18:

Gravitational Effect of Pressure

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$$\dot{\rho}_{\text{vac}} = 0 \quad \Longrightarrow \quad p_{\text{vac}} = -\rho_{\text{vac}}c^2 = -\frac{\Lambda c^4}{8\pi G} \ .$$

Defining $\rho = \rho_n + \rho_{\rm vac}$ and $p = p_n + p_{\rm vac}$,

$$\frac{d^2a}{dt^2} = -\frac{4\pi}{3}G\left(\rho_n + \frac{3p_n}{c^2} - 2\rho_{\rm vac}\right)a \ .$$

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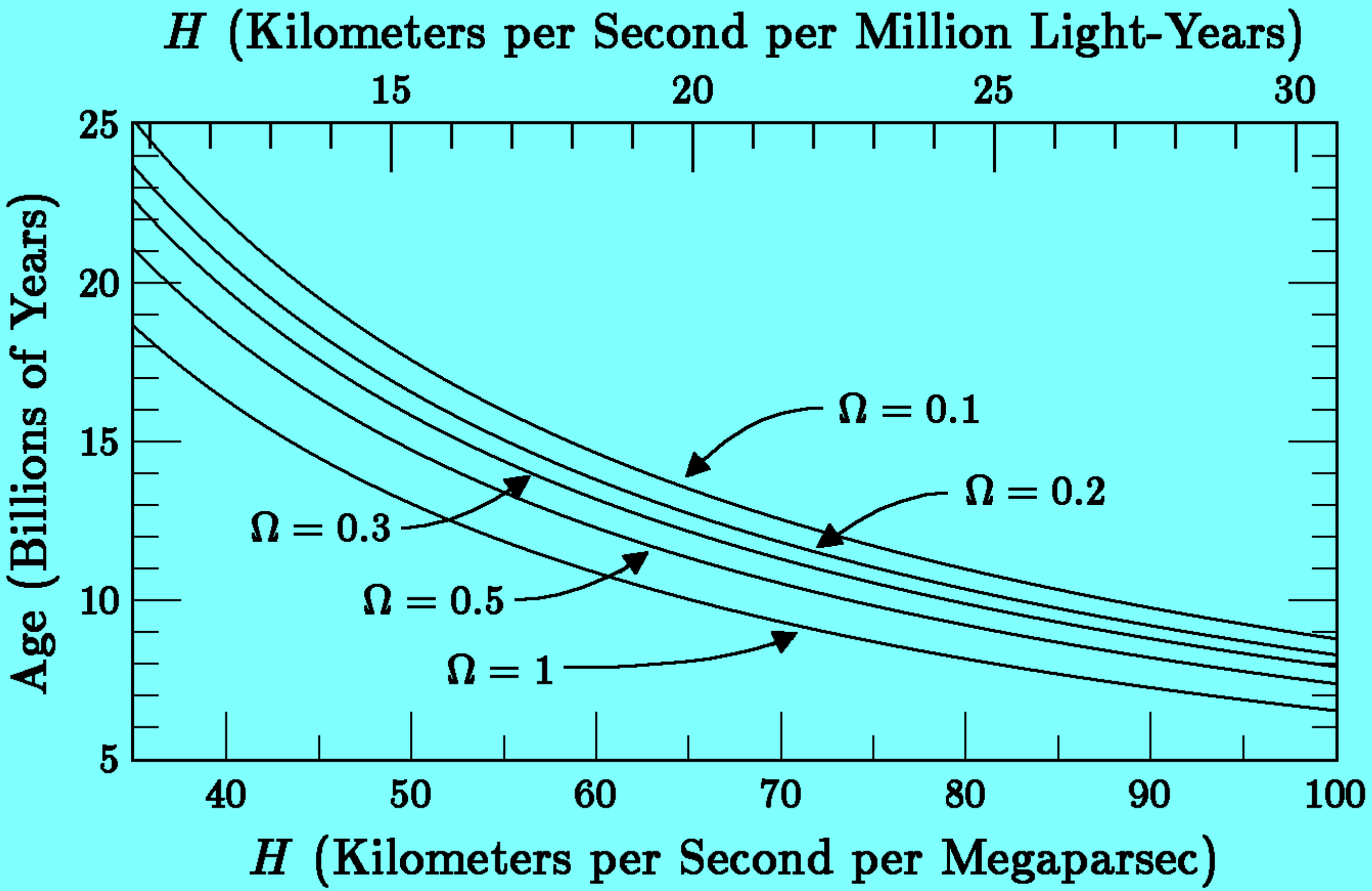
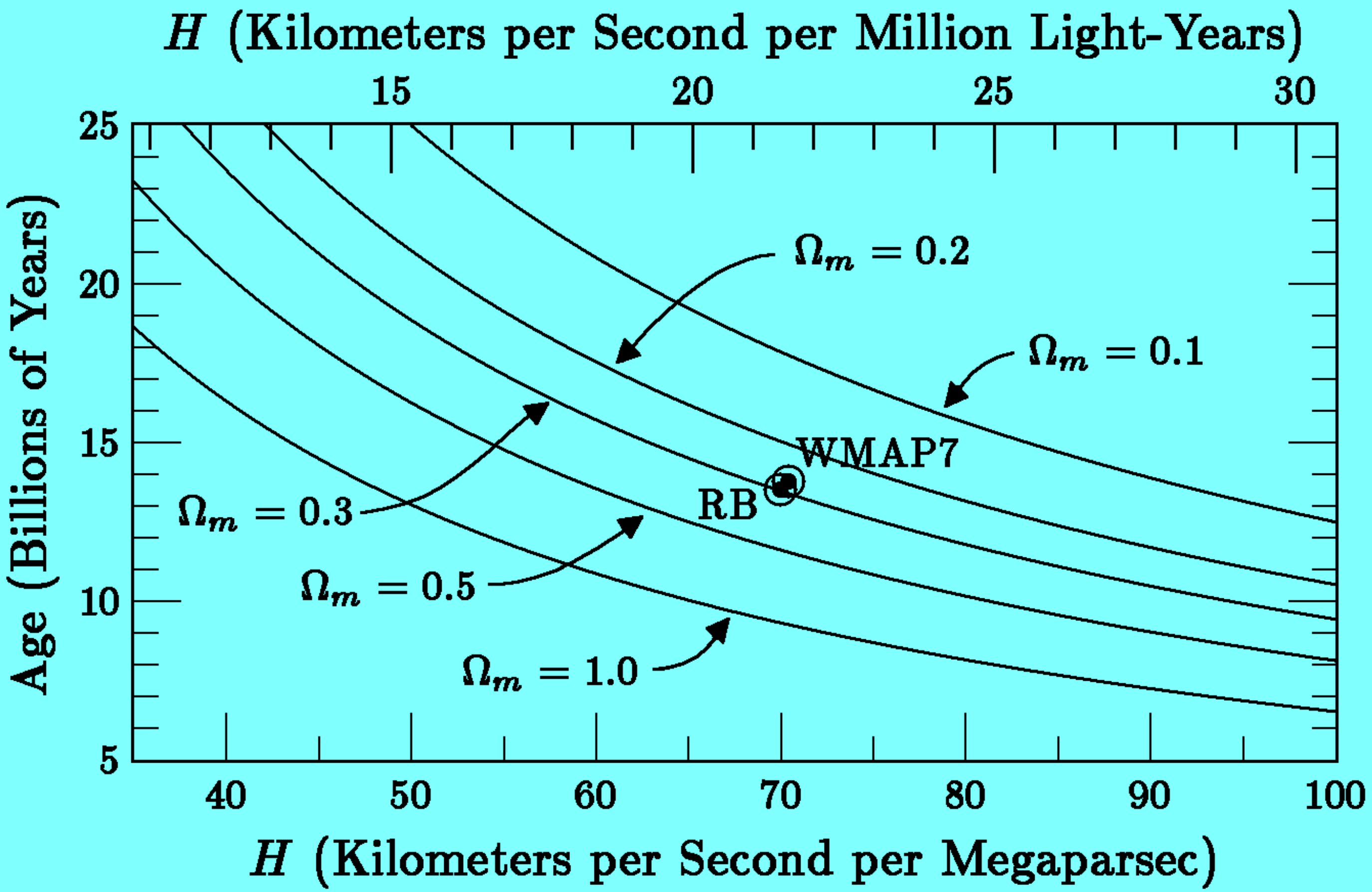
Dominance of vacuum energy at late time implies

$$H \to H_{\rm vac} = \sqrt{\frac{8\pi}{3}G\rho_{\rm vac}}\ ,$$

$$a(t) \propto e^{H_{\rm vac}t}\ .$$



The age of an open ($\Omega < 1$), closed ($\Omega > 1$), or flat ($\Omega = 1$) universe containing only nonrelativistic matter.



The age of a flat universe containing nonrelativistic matter and vacuum energy.