Copernicus, Doppler, Michelson and cosmology

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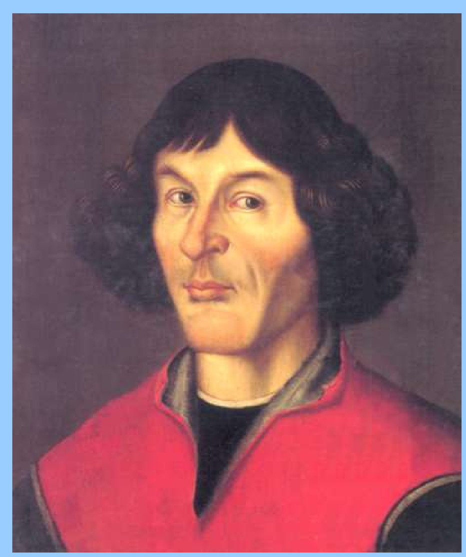
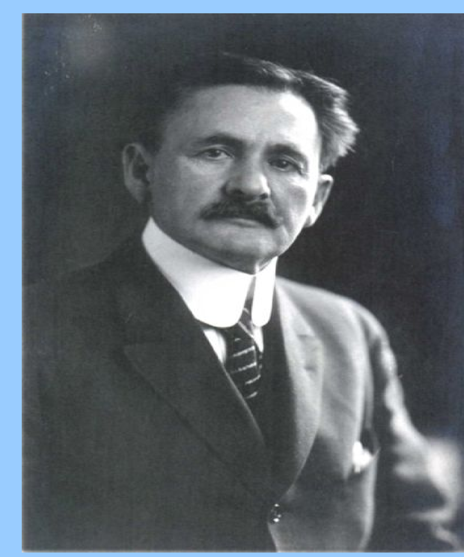
The negative result of Michelson and Morley's experiment embarrassed scientists for almost 20 years, until Einstein's work on „Electrodynamics of moving objects" and Poincare's postulate of relativity. The precision of that experiment was 1/6 of the predicted Earth's orbital movement. It has been repeated several times, with renewed technical solutions: 1) stabilized temperature within 0.001 K and different paths by Kennedy and Thorndike (1932) who cleared that both time and distance are subject to Lorentz- Einstein contraction, 2) infrared modes of He-Ne laser by Jaseja et al. (1964) who excluded the ether wind within 1/1000 of the Earth's orbital velocity. But starting from 70'ies, i.e. after the discovery of the cosmic 2.725 K microwave background radiation, articles change titles from searching the „ether" drift to the check of "isotropy of space". A clear dipole Doppler shift of 0.00335 K is seen in this background: the Solar system moves in respect to this background by 368 km/s. Only by subtracting this shift from the measured cosmic background temperature one gets a nice, well known from COBE and WAMP satellites, "spätzle" picture of the initial inhomogenities of early Universe plasma. The Doppler effect allows to establish our place in Universe – Copernicus was right, we are not in the centre.



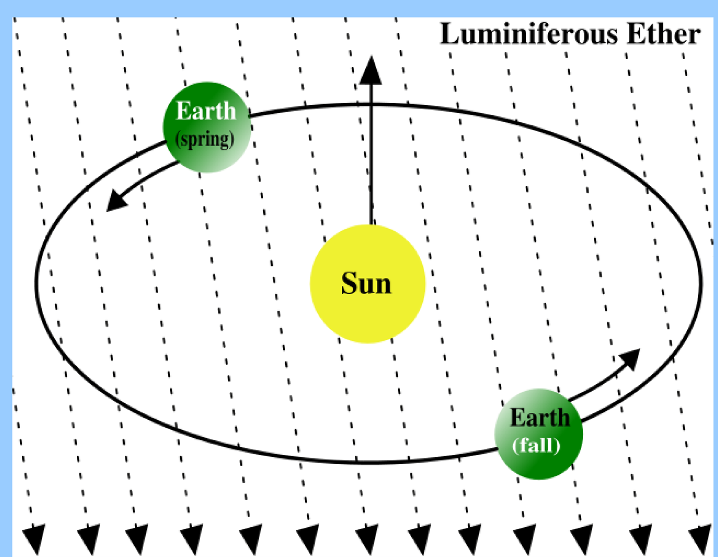
Nicolaus Copernicus, born 19 February 1473 (Toruń, Poland) – died 24 May 1543 (Frombork, Poland)

Christian Andreas Doppler: born 29 November 1803 (Salzburg, Austria) – died 17 March 1853 (Venice, Italy)



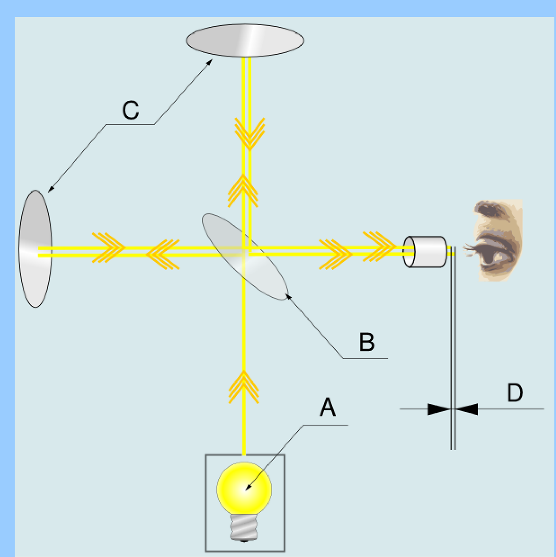
Albert Abraham Michelson: born 19 December 1852 (Strzelno, Poland) – died 9 May 1931 (Pasadena, USA)

Doppler effect and Michelson-Morley experiment



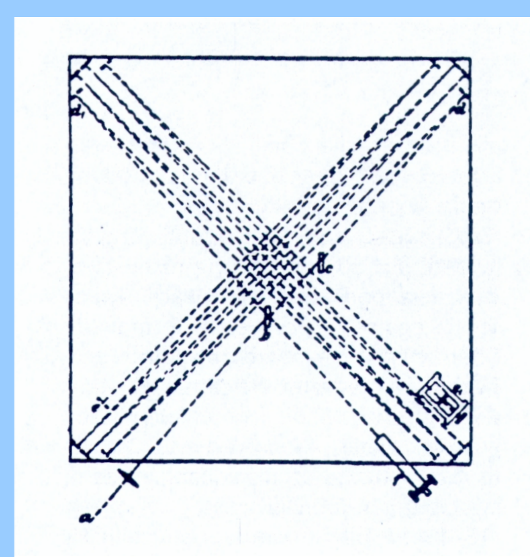
The concept of the ether [7].

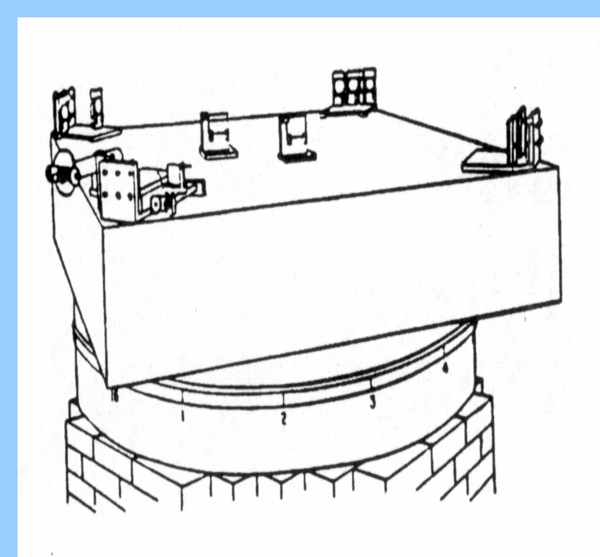
In the late 19th century **ether** was the term used to describe a medium for the propagation of light. It was hypothesised that the Earth moves through a "medium" of ether that carries light.



The scheme of the Michelson interferometer: A – source of light, B – beam splitter, C – mirrors, D – screen.

Any slight change in the amount of time the beams spent in transit would then be observed as a shift in the positions of the interference fringes. If the ether were stationary relative to the sun, then the Earth's motion would produce a fringe shift 0.04 the size of a single fringe.



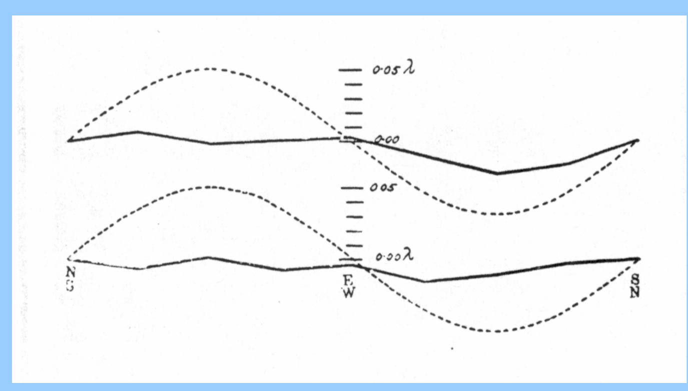


In the Michelson-Morley experiment, the light was repeatedly reflected back and forth along the arms, increasing the path length to 11 m [2]. At this length, the drift would be about 0.4 fringes. To make that easily detectable, the apparatus was located in a closed room in the basement of a stone building, eliminating most thermal and vibrational effects. Vibrations were further reduced by building the apparatus on top of a huge block of marble, which was then floated in a pool of mercury. They calculated that effects of about 1/100th of a fringe would be detectable. The mercury pool allowed the device to be turned, so that it could be rotated through the entire range of possible angles to the "ether wind."

$$f_o = f_s \frac{1}{\gamma\left(1 - \frac{v\cos\theta_o}{c}\right)}$$

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

If, in the reference frame of the observer, the source is moving away with velocity v at an angle Θ_o relative to the direction from the observer to the source (at the time when the light is emitted), the frequency changes.

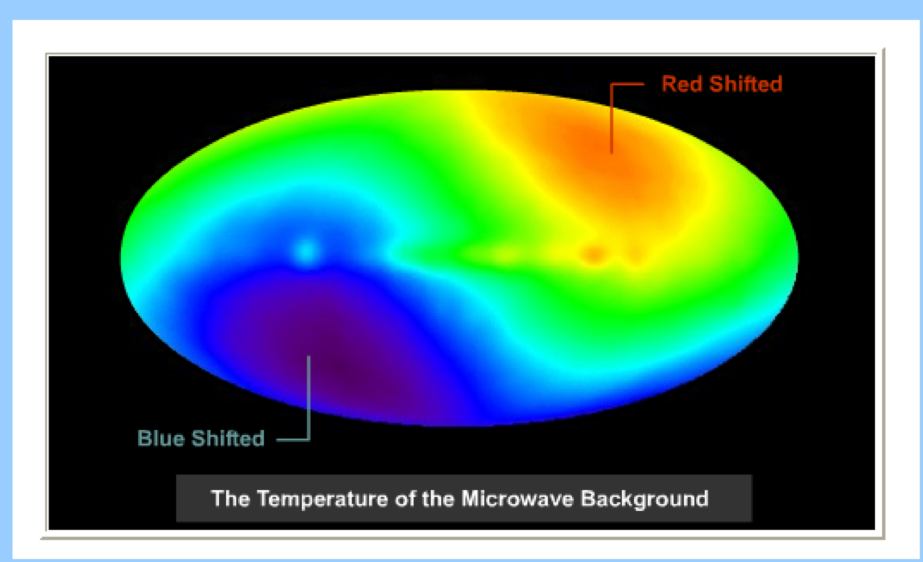


The results of the observations of Michelson and Morley from the paper „On the relative motion of the Earth and the luminiferous ether" [2]. The upper is the curve of observations at noon, and the lower for the evening observations. The dotted curves represent the theoretical displacements.

Doppler effect in cosmology

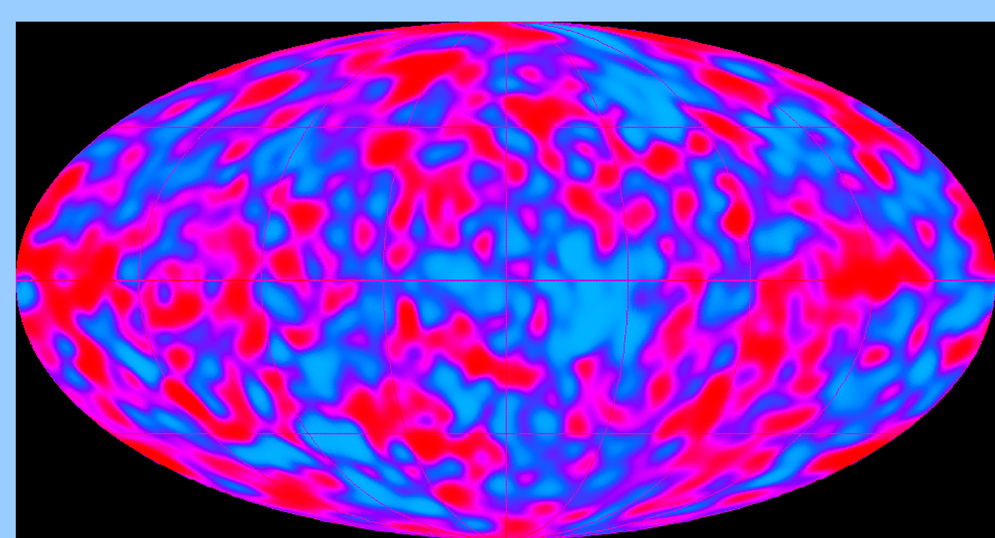
Cosmic Microwave Background Anisotropy

The anisotropy of the cosmic microwave background (CMB) consists of the small temperature fluctuations in the blackbody radiation left over from the Big Bang. The average temperature of this radiation is **2.725 K** as measured by the COBE satellite. There are small temperature fluctuations superimposed on this average. One pattern is a plus or minus 0.00335 K variation with one hot pole and one cold pole: a dipole pattern. A velocity of the observer with respect to the Universe produces a dipole pattern with ***dT/T = v/c*** by the Doppler shift. The observed dipole indicates that the Solar System is moving at 368 ± 2 km/s relative to the observable Universe in the direction galactic longitude l=263.85° and latitude b=48.25° with an uncertainty slightly smaller than 0.1°.



The changes of the temperature (± 3 mK) of the Cosmic Microwave Background measured bye COBE.
COBE Dipole: Speeding Through the Universe
Astronomy Picture of the Day, June 27, 1999.

http://csep10.phys.utk.edu/astr162/lect/cosmology/cbr.html



The changes of the temperature (± 27 μK) of the Microwave Background measured bye COBE.

A microwave map of the whole sky made the Cosmic Background Explorer (COBE) Differential Microwave Radiometer (DMR).

http://map.gsfc.nasa.gov/m_mm.html

References

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