Measuring the frequency of light

Preface

Physics does not need proofs of the speed of light for the convinced, it needs it for doubters. Physics needs simple and easy-to-understand proofs. This paper outlines basic measurements of light properties. It is interesting that easy-to-understand measurements do not appear in the professional literature. The measurement methods presented in this paper have not been used throughout the history of physics.

Measuring the light from a comet Hale-BOPP

On the WHAM instrument used to measure the light from a comet (*6300 Large Aperture Photometry of Comet Hale-BOPP*), we generally observe two spectral lines, Λ and F. One spectral line generated by the comet appears on the instrument in the form of two brightness peaks.

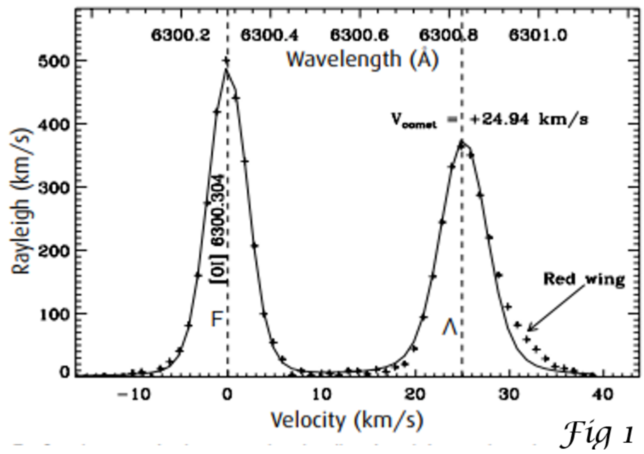

Fig 1

The comet's velocity does not affect the wavelength of the spectral line Λ. The spectral line F, on the other hand, changes the wavelength, as described in Doppler's law, according to the comet's velocity.

The WHAM light wavelength meter used to measure light from comet Hale-BOPP was aimed at the comet's head. For the purpose of directing the telescope, a grid is installed between the telescope and the wavelength meter, as shown in Fig 2. The grid retains some of the light and redirects it towards the operator's eye.

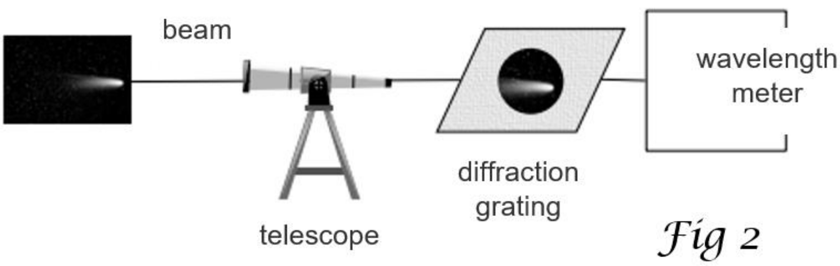

Fig 2

A key element in the separate measurement of the frequency and wavelength of light is the diffraction grating. The grid is not installed just to direct the telescope. It also inadvertently performs the function of a diffraction grating, although the measurements do not mention that this would be its purpose.

The diffraction grating changes the wavelength of the light

If there is no diffraction grating between the telescope and the wavelength meter, only the spectral line Λ is observed. When a diffraction grating is inserted between the telescope and the wavelength meter, the spectral line F appears. The diffraction grating therefore changes the wavelength of the light.

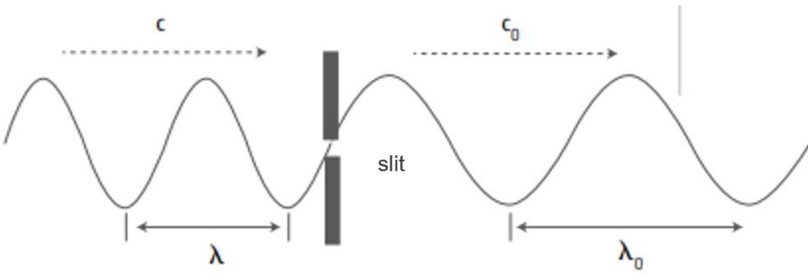

Fig 3

We do not have to wait for a comet to repeat the described measurement. Measurements can be repeated based on light from Mars or Jupiter. The described properties of light can be verified by measurements by many astronomical laboratories.

Measuring the change in the wavelength of the spectral line F after the diffraction grating in Fig 3 gives the possibility of measuring the frequency of light.

Physicists generally believe that the wavelengths of light at the transition of the diffraction grating do not change. If the measurement of the effect of a diffraction grating on wavelength were made, physicists would know, not just believe. Even more important, however, is this measurement for skeptics. Doubters would get an unambiguous and definitive answer to the question of the speed of light by measuring; measurement the effect of the diffraction grating on the wavelength and measurement of how the speed of the light source affects the wavelength of the light. These two measurements this would remove all doubts. None of these measurements were made in the circumstances of near space where we know exactly the light source and the speed of the light source.

The wavelength meter as well as a light frequency meter

Fig 4 shows the schematic representation of the wavelength meter as well as the light frequency meter; each measurement separately.

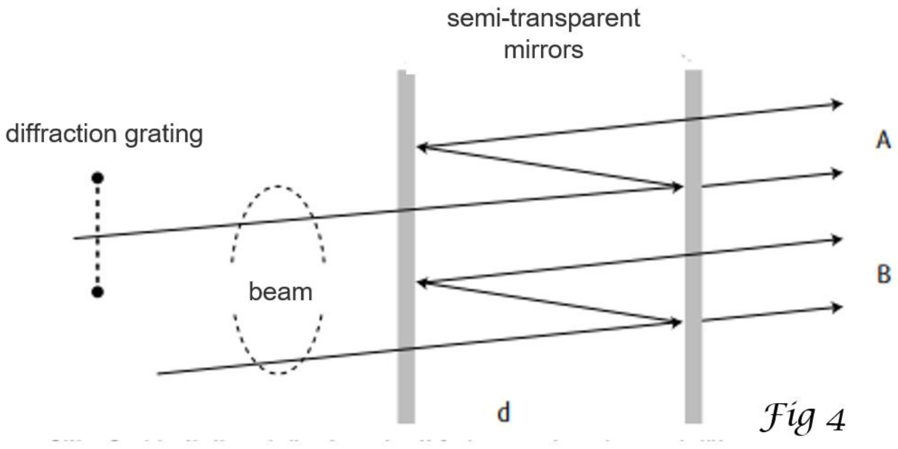

Fig 4

The beam arrives from the left on the entrance of the instrument. At the entrance, it is separated into beam A and beam B. Beam A travels through a diffraction grating in front of a semi-transparent mirror, as shown in *Fig 4*. The second part of the beam, marked B, travels directly to the semi-transparent mirror near by the diffraction grating.

Measurement of the wavelength of light has been known since 1899. It is possible by the Fabry-Pérot interferometer. The beam B in the Fig 4 travels through the first mirror. On the other mirror, part of the beam reflects and part of the beam continues its path. The reflected beam reflects one more from the first mirror, returns to the second mirror, and passes it.

The two beams in Fig4, marked with the letter B, merge behind the second mirror and create interference. They create interference when the distance between the mirrors is a multiple of the wavelength of the beam. The interference of the beams is shown in the form of a light peak of the spectral line Λ in the *Fig 1*. The measured wavelength of light does not depend on the frequency of light.

The frequency of light is measured on the basis of the beam A shown in the *Fig 4*. Semi-transparent mirrors measure wavelength of beam A in the same way as the beam B. The difference is that the diffraction grating changes the wavelength of beam A before the beam enters the semi-transparent mirror, as explained in *Fig 3*.

Beam A hits a semi-transparent mirror of the Fabry-Pérot interferometer with a different wavelength than beam B. As a result, beams A and B create a spectral line each at its own wavelength – Fig 1.

The spectral line Λ shows the wavelength of light (λ) that arrives directly from the comet to the interferometer near by the diffraction grating. The spectral line F appears at the wavelength λ_f. This is removed by as much as the diffraction grating changes the wavelength of the beam A.

The speed of light between the diffraction grating and the semi-transparent mirror is always equal to the constant c. On the other hand, the frequency of light on the diffraction grating does not change. The frequency of the measured light on the interferometer is the same before and also behind the diffraction grating.

Two parameters are known between the diffraction grating and the semi-transparent mirror. We know the speed of light. We also know the wavelength of light measured by the spectral line F. We can find the frequency of light from these two known parameters.

$$f = \lambda_f / c$$

It is different in case of beam B. In the case of beam B, we do not know the speed of the beam. However, beam velocities are not needed to measure the wavelength of light. Beam A thus makes it possible to measure the frequency of light, and beam B its wavelength.

Technologically undemanding measurement of frequency and wavelength means our liberation from the postulates of the speed of light to scientific measuring a speed of light in various circumstances.

Conclusion

Measuring the frequency of light, independent from measuring the wavelength of light, is not technologically demanding. The existing equipment of many astronomical observatories allows separate measurement of the frequency of light and its wavelength. This makes it possible to measure the speed of light in different circumstances in which the speed of light has not yet been measured.