Doppler phenomenon

The **Doppler phenomenon** represents a change in the detected frequency of waves when the source and detector are in relative motion. The physical essence of the Doppler effect is the addition of the wave speed with the speed of the relative movement of the source and the detector. The phenomenon applies to any wave, i.e. mainly acoustic and electromagnetic. It was first described by Christian Doppler as a shift of spectral lines in rotating binaries, where the spectrum of a star moving towards us shifted towards the blue end and the spectrum of a star moving away from us towards the red end of the spectrum. For medicine, by far the most important is the Doppler phenomenon in the reflection of ultrasound from moving particles, especially red blood cells.

A typical situation of use in medicine is a standing observer, i.e. a fixed detector, and a moving source, i.e. tissue reflecting the waves incident on it. For the wavelength of the detected ripple then:

$$\lambda = \lambda_0 \pm \frac{v_{zdr}}{f_0}$$

The sign is determined by whether the sound source is moving away (+) or closer (-) to the detector, λ_0 is the wavelength of the wave leaving the source, f_0= the original frequency of this ripple wave and v_{zdr} is the velocity of the source.

The basic use is to detect the flow of blood. A typical combination of color-coded information about blood flow into an ultrasound image in B mode, so-called duplex sono. In angiology, pencil flowmeters are also used, which only detect movement and signal it by sound output.

The arrangement is somewhat more complicated in this case. The wave is sent by the probe and falls on the tissue, which acts as a "detector". In the tissue, it is already reflected with a shifted frequency and returns as a wave from the moving source back to the probe, which also functions as a detector. So there are two frequency shifts. For the difference between the detected and transmitted frequency, the relationship applies:

$$\Delta f = \frac{2inf_0}{c} \cos \alpha,$$

where $\boldsymbol{v}$ is the velocity of the tissue movement, $\boldsymbol{c}$ is the wave velocity, and $\boldsymbol{\alpha}$ is the angle subtended by the vector tissue movement speed with the axis of the probe.

Related Articles

- Doppler ultrasonography in medicine • Doppler ultrasonography
- Doppler imaging
- Doppler echocardiography • Transcranial Doppler ultrasonography • Fetal Dopplermetry • Doppler flowmeter

References

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