Light Speed(s)

1. Simple definitions

Let ω be the angular velocity and *k* the wavenumber[1], then the phase velocity V_f is defined as

$$V_f=\varpi/k \qquad (1)$$

The group velocity is the velocity with which energy propagates and is defined by

$$V_g= \delta\varpi/\delta k \qquad (2)$$

2. The case of light

If a wave satisfies the dispersion relation then:

$$\varpi(k) = \sqrt{k^2c^2 + const} \qquad (3)$$

Expression (3) is exactly the case for light.

From (1), (2) and (3) we obtain

$$V_g*V_f=c^2 \qquad (4)$$

In (4) V_f or V_g can be greater than c or even negative. Though V_f or V_g may exceed c no energy or information actually travels faster than c. Experiments showing group velocities greater than c include that of Wang *et al.*[2], who produced a laser pulse in atomic cesium gas with V_g between (-310+5)c and (-310-5)c. V_f is in the range –c/305 to –c/315.

3. References

1. Feynman, Leighton and Sands (vol1) Addison-Wesley
2. Wang, L. J.; Kuzmich, A.; and Dogariu, A. "Gain-Assisted Superluminal Light Propagation." *Nature* **406**, 277-279, 2000.