phase, group velocity formula written in terms of wavelength

$$c(k) = \frac{\omega(k)}{k} \qquad u(k) = \frac{d\omega(k)}{dk}$$

$$u(k) = \frac{d}{dk}\left(c(k)\,k\right) = k\frac{dc(k)}{dk} + c(k)$$

$$u(k) = c(k) + \frac{2\pi}{\lambda}\frac{dc(k)}{dk}$$

$$k = 2\pi\lambda^{-1}$$

$$\frac{dk}{d\lambda} = -2\pi\lambda^{-2} \qquad \text{and} \qquad \frac{d}{dk} = \frac{d\lambda}{dk}\frac{d}{d\lambda}$$

$$\frac{d}{dk} = -\frac{\lambda^2}{2\pi}\frac{d}{d\lambda}$$

$$\boxed{u(\lambda) = c(\lambda) - \lambda\frac{dc}{d\lambda}}$$

note that $\frac{dc}{d\lambda}$ is positive for cases shown at right so that $u(\lambda) \leq c(\lambda)$.

where $\frac{dc}{d\lambda}$ is maximum, ie at the inflection in the phase velocity curve, $u(\lambda)$ has a minimum.