Reflection seismic 1
script

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Seismic waves

- Wave propagation
  - Hook's law
  - Newton's law
  - $\Rightarrow$ wave equation
- Wavefronts and Rays
- Interfaces
- Reflection and Transmission coefficients

Seismic Waves

body waves

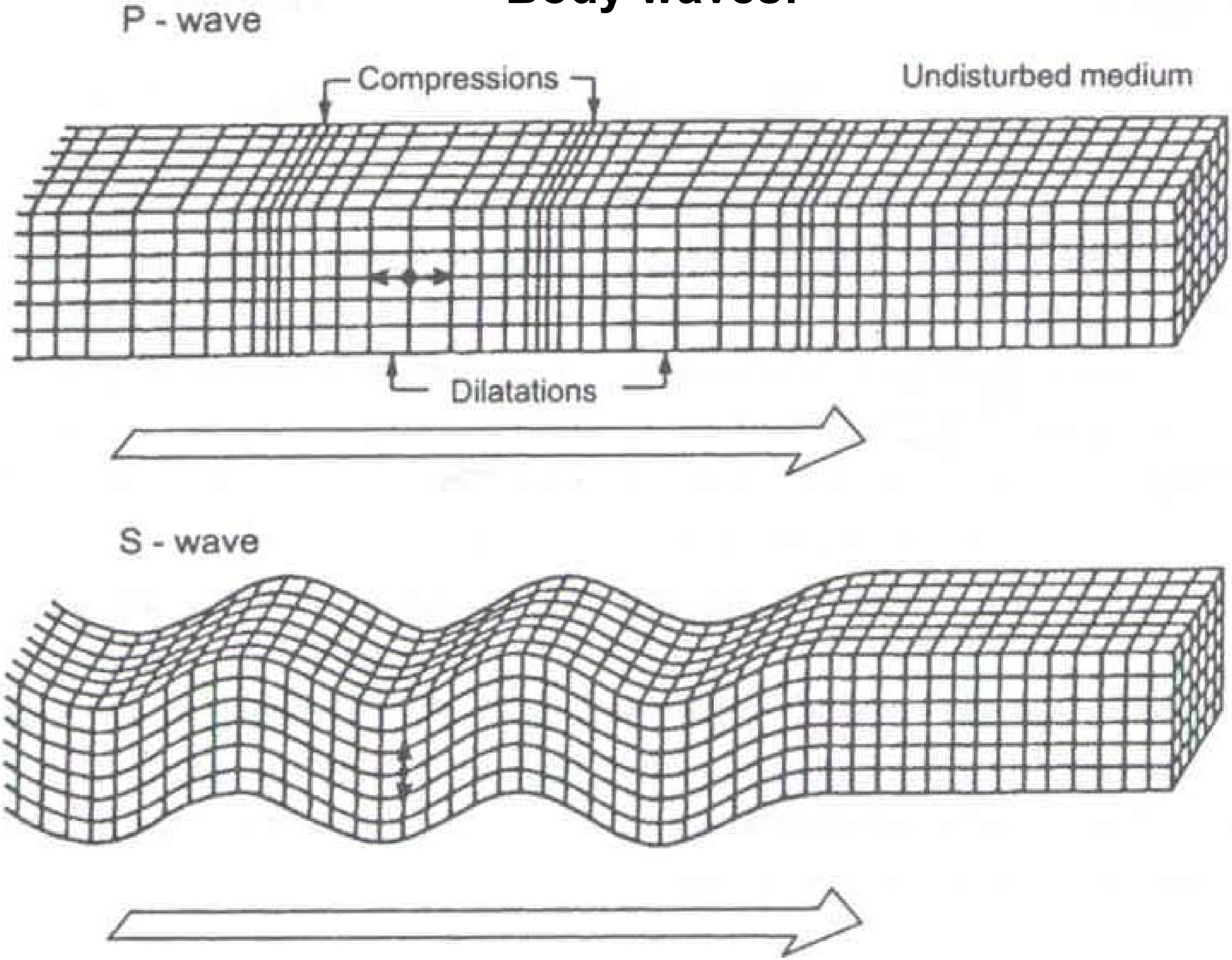
P-waves (longitudinal, compressional)

S-waves (shear, transverse)

S_V-wave

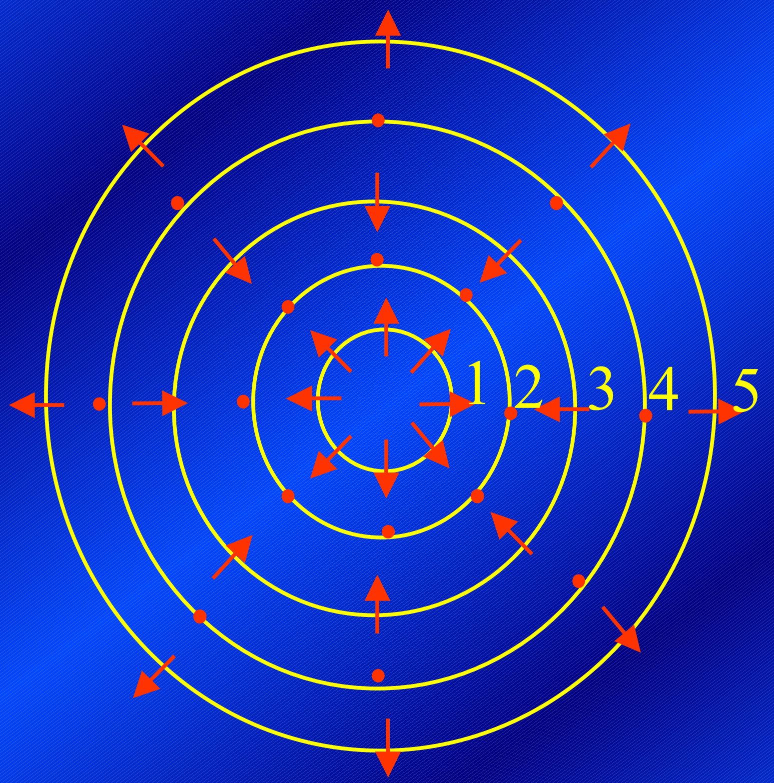
S_H-wave

Body waves:

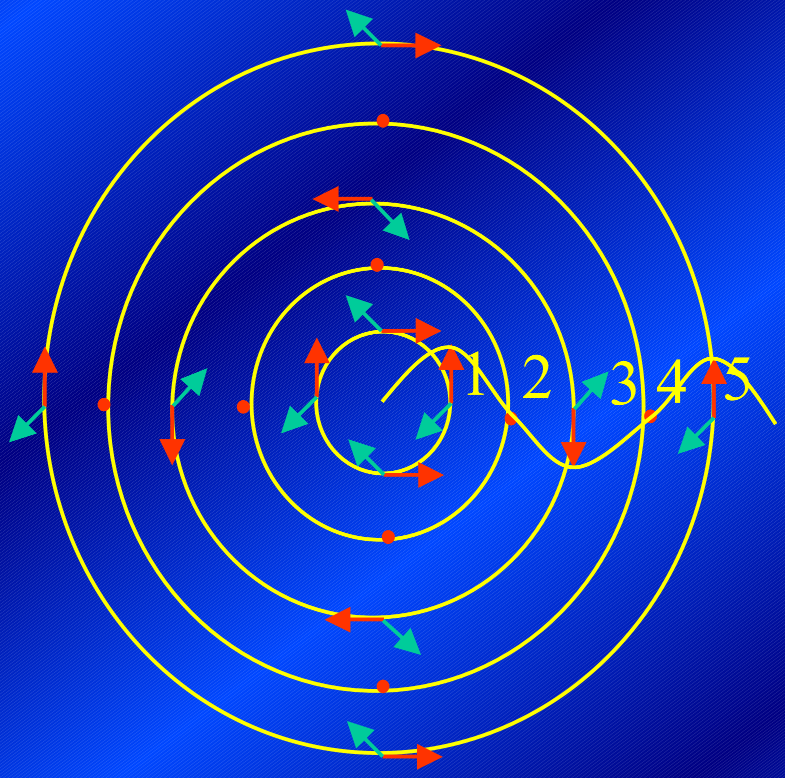

P - wave
Compressions
Undisturbed medium
Dilatations
S - wave

Different kind of waves

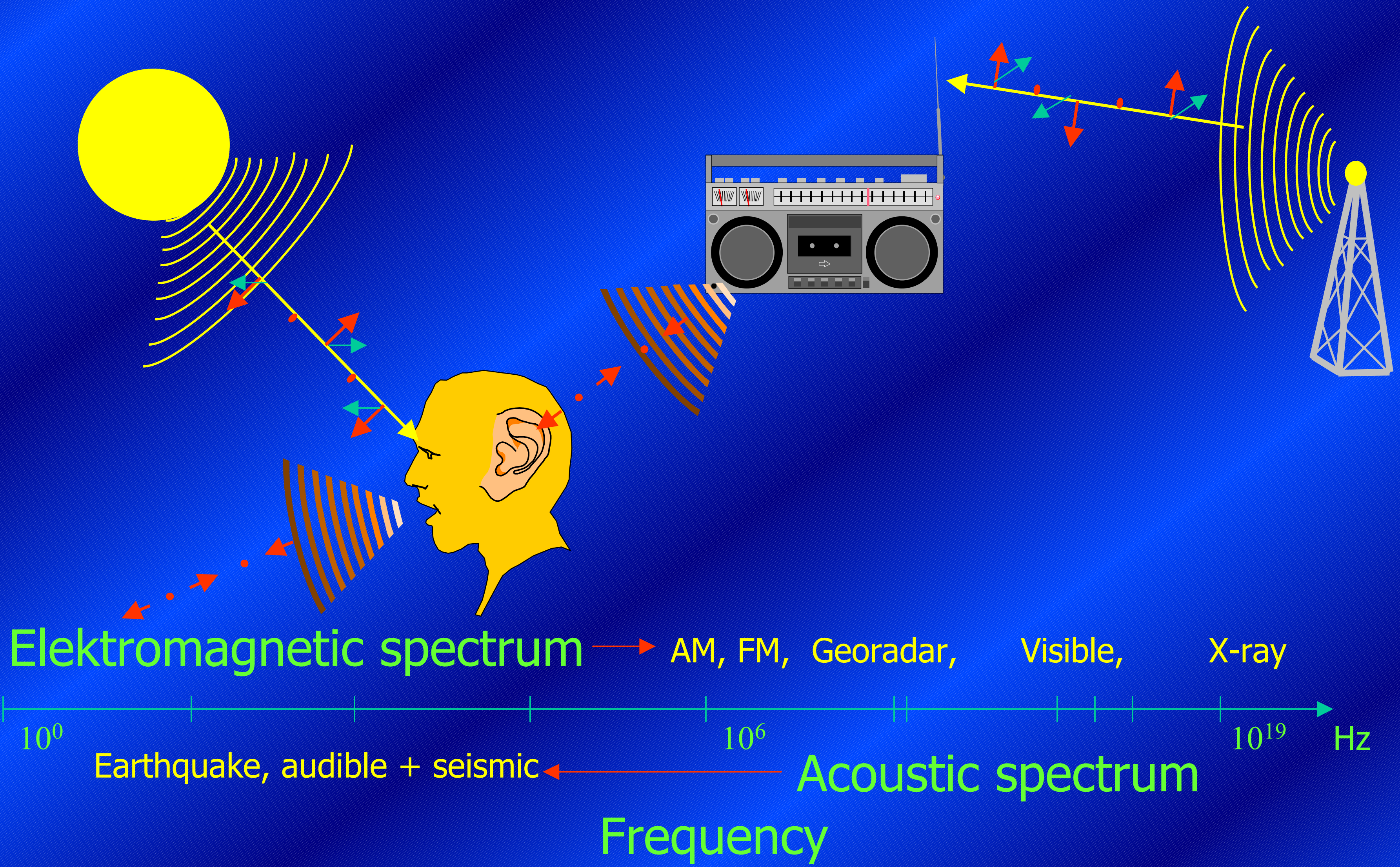
- Longitudinal waves (P-waves)



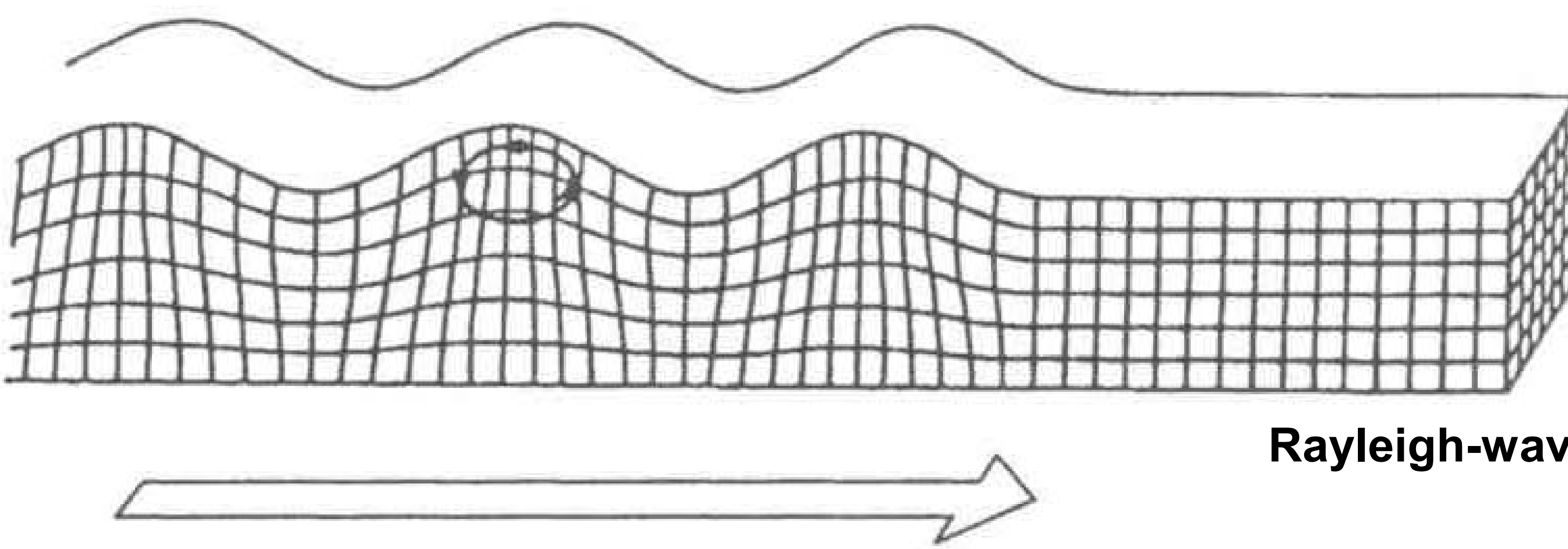
- Transversal waves (S-waves)



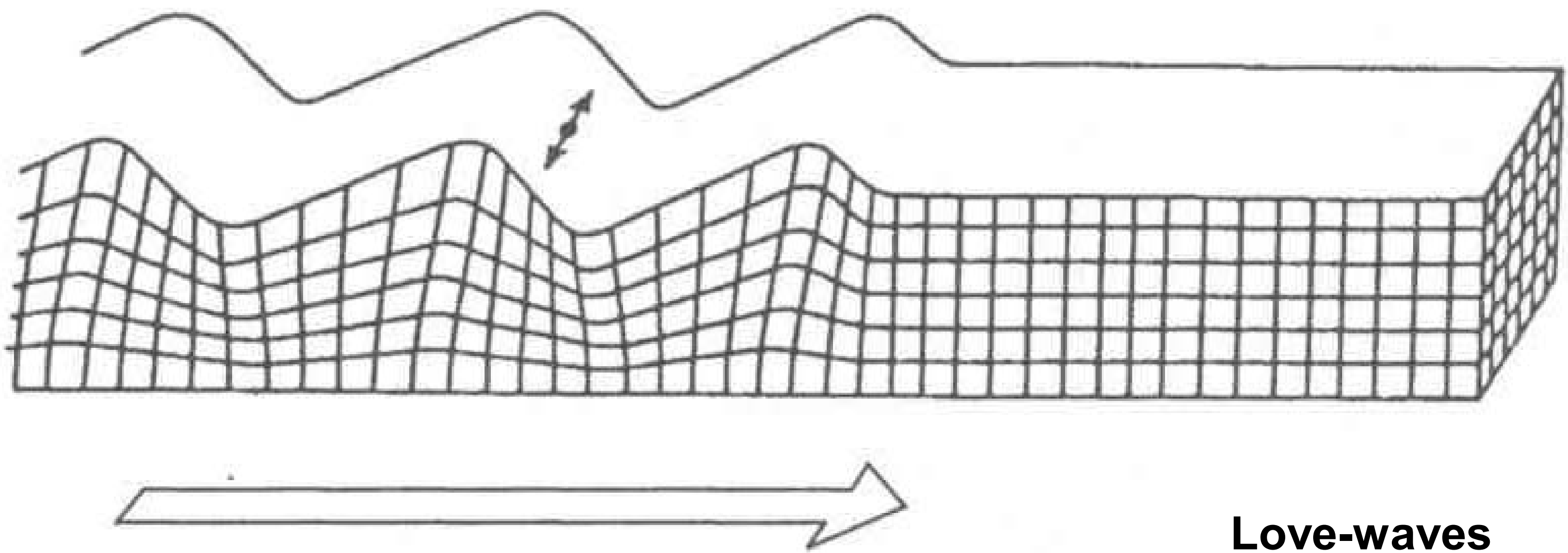
Examples of different waves



Surface waves

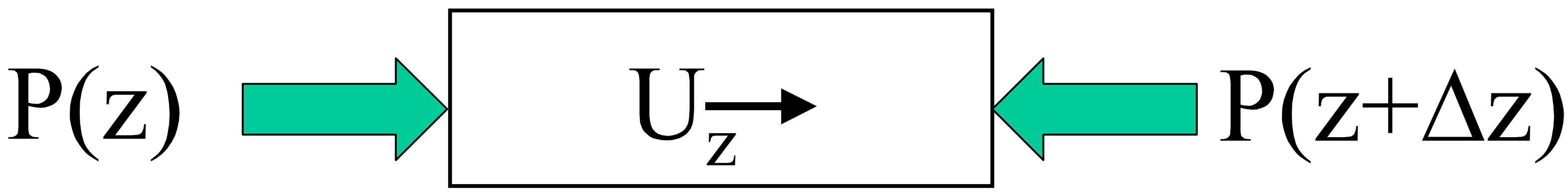


Rayleigh-waves



Love-waves

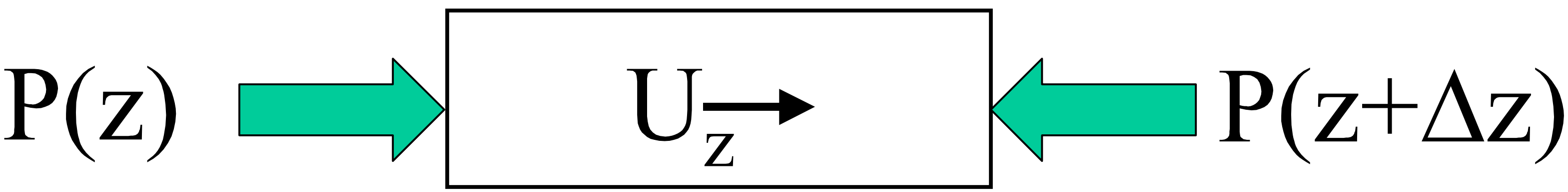
Newton's law



$$P(z+\Delta z) - P(z) = -\rho\, \Delta z \frac{d^2}{dt^2} U_z$$

ρ is the massdensity

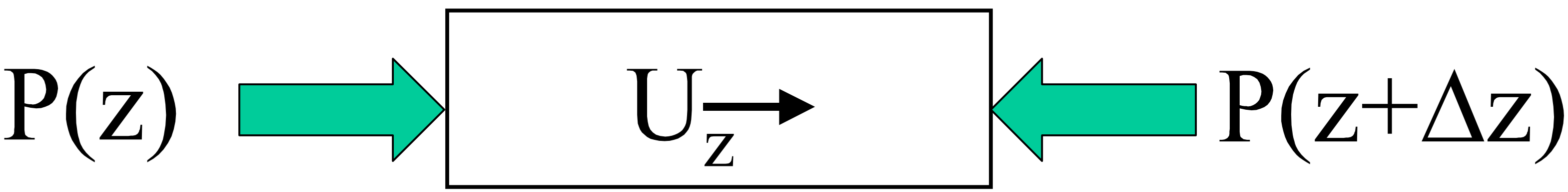
Newton's law



P is the acoustic pressure

U_z is the displacement

Newton's law



$$\frac{\partial}{\partial z} P = -\rho \frac{\partial^2}{\partial t^2} U_z$$

Hook's law

$$U_z(z+\Delta z) - U_z(z) = -\kappa \, \Delta z \, P$$

κ is the compressibility

Hook's law

$$\frac{\partial}{\partial z} U_z = -\kappa P$$

Acoustic Expressions

$$\frac{\partial}{\partial z} P + \rho \frac{\partial^2}{\partial t^2} U_z = 0$$

$$\frac{\partial}{\partial z} U_z + \kappa P = 0$$

Acoustic expressions with source term

$$\frac{\partial}{\partial z} P + \frac{\partial^2}{\partial t^2} U_z = 0$$

$$\rho$$

$$\frac{\partial}{\partial z} U_z + \kappa P = q\, \delta(z)$$

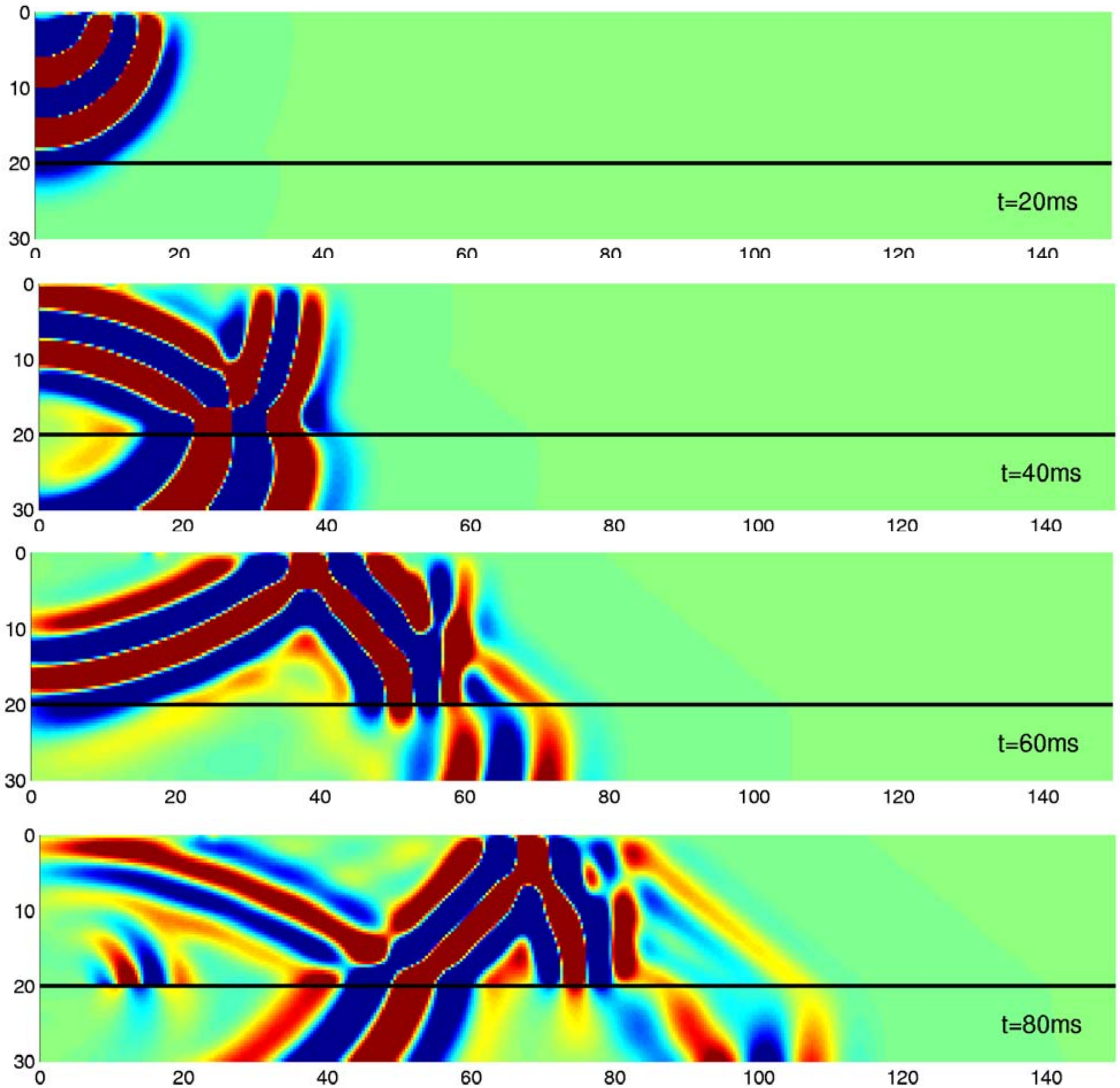
$\delta(z)$ is the Dirac function

Acoustic Wave equation

$$\frac{\partial^2}{\partial z^2} P - \frac{1}{c^2} \frac{\partial^2}{\partial t^2} P = -w(t)\, \delta(z)$$

$$w(t) = \rho \frac{\partial^2}{\partial t^2} q(t) \quad \text{(sourcesignal)}$$

$$c = (\rho\kappa)^{-1/2} \qquad \text{(wavespeed)}$$



(Roth et al., 1998)

Objecten detecteren met behulp van **Golven**

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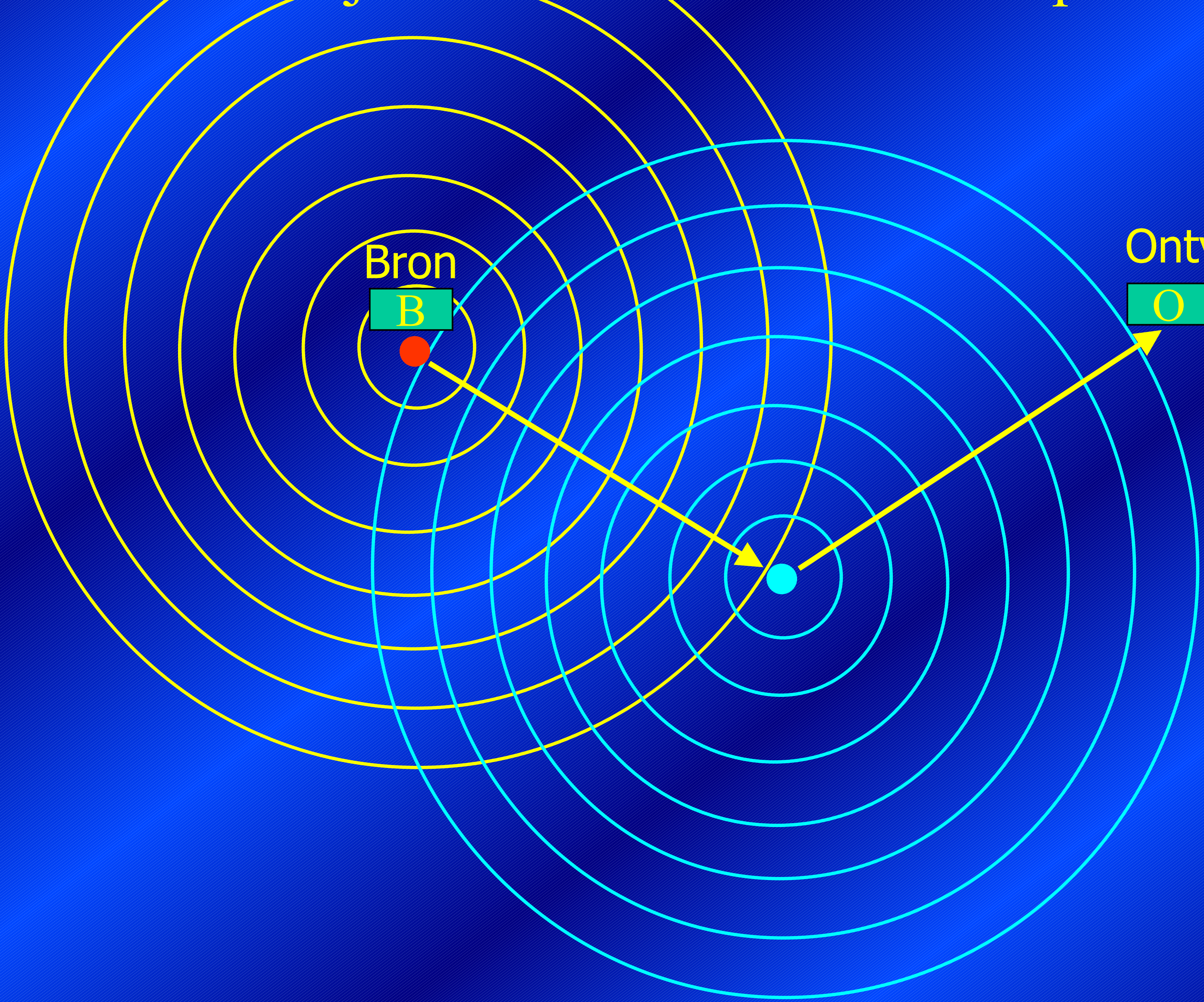
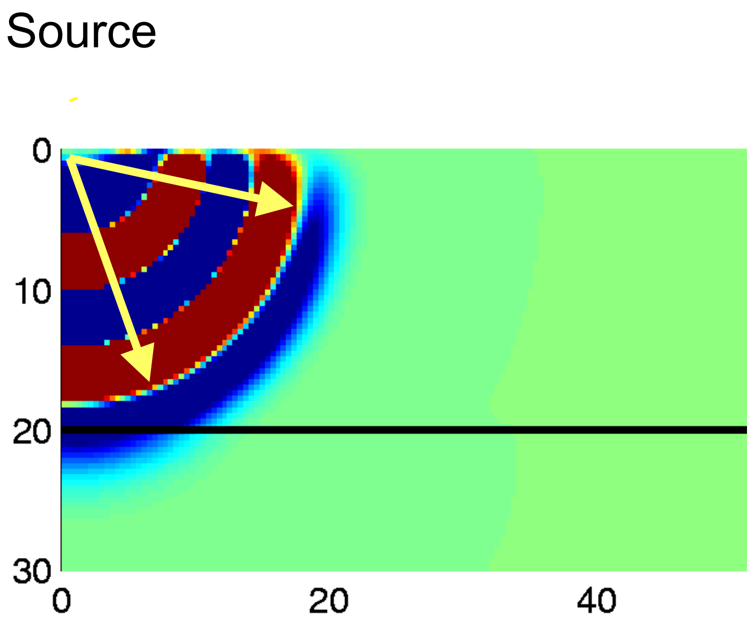


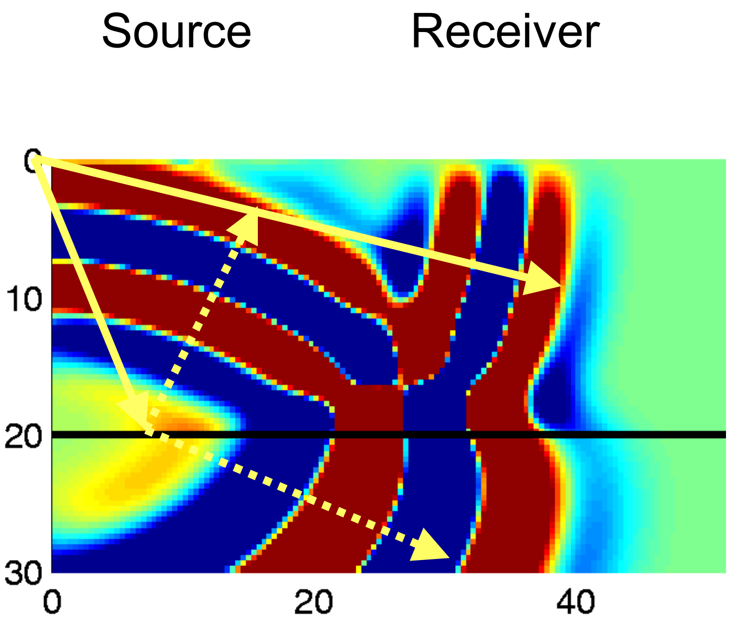
Wavefronts versus Rays

- Wavefronts indicate the boundary of the material which allready moves and the material which is still undisturbed.

- Rays are plotted perpendicular with respect to the wavefronts and describe the dominant propagation of the seismic energy between two locations

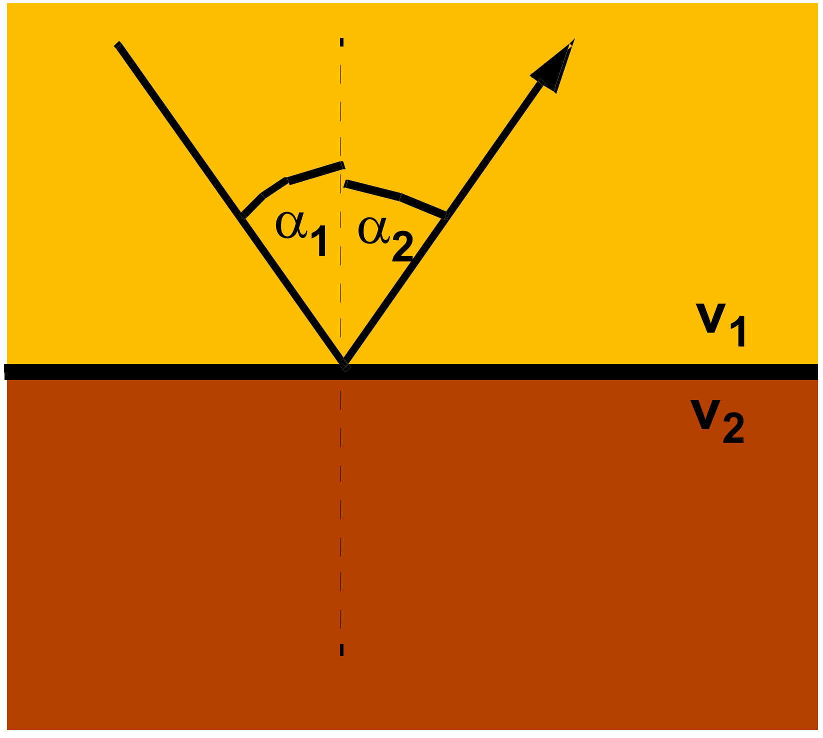
Geometrical Wavepropagation





→ **Consider wavefronts as rays, perpendicular to the wavefronts**

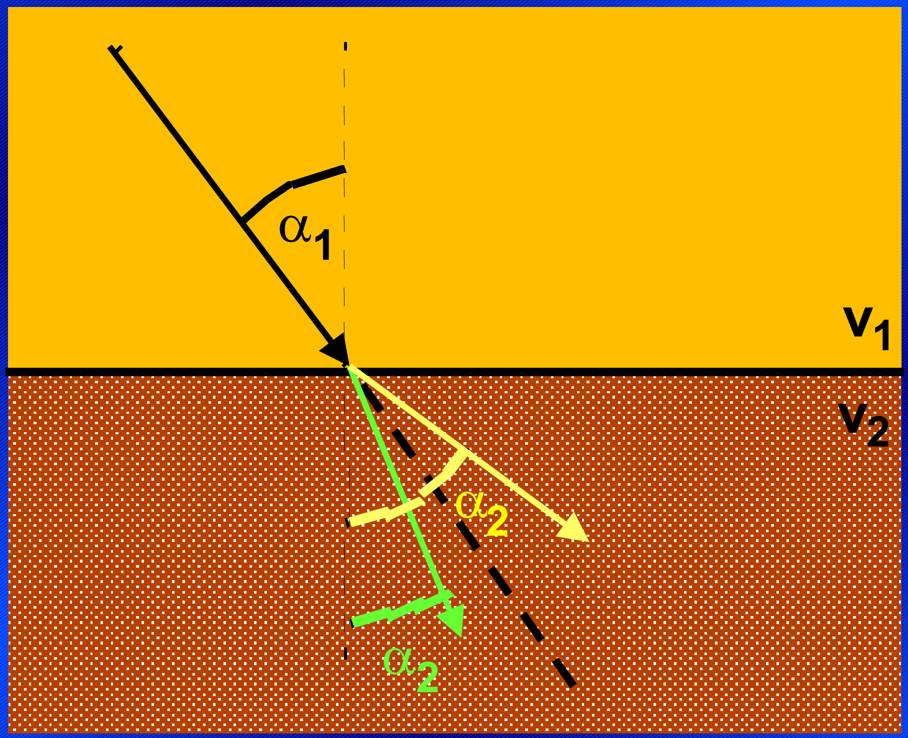
Interface: reflection



Angle of incidence = angle of reflection

$$\alpha_1 = \alpha_2$$

Interface: Refraction

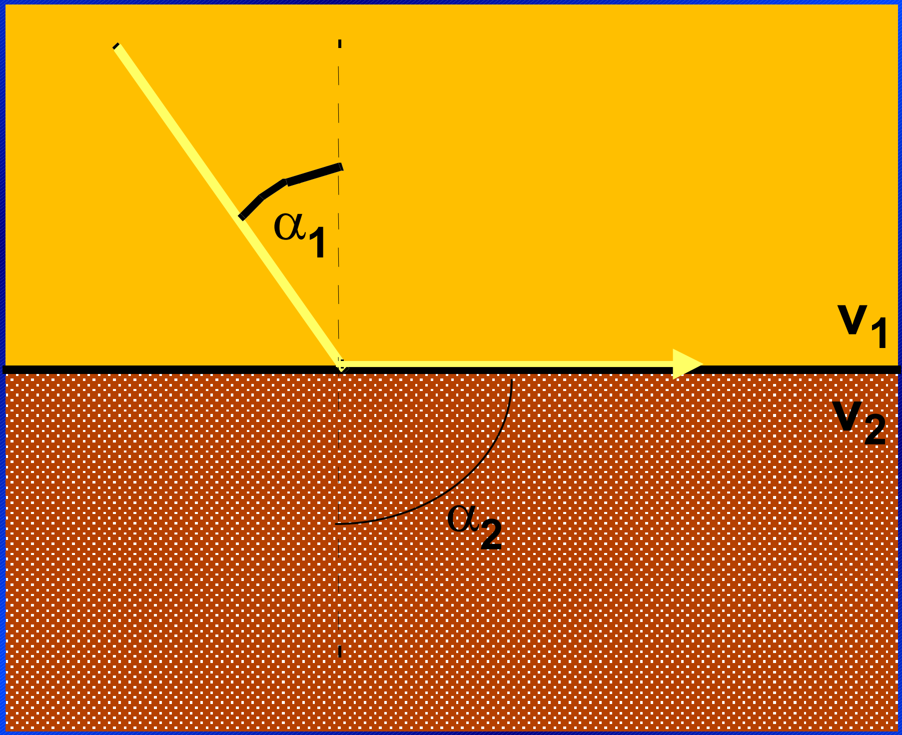


$$\frac{\sin \alpha_1}{\sin \alpha_2} = \frac{v_1}{v_2}$$

$v_2 > v_1$

$v_2 < v_1$

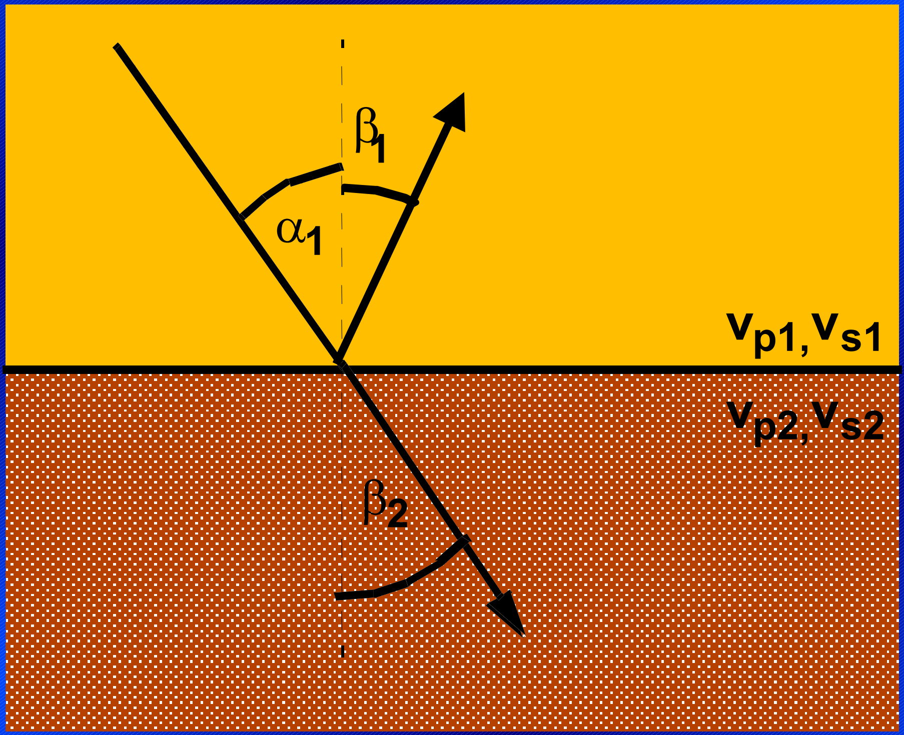
Special case: critical angle



$\alpha_2 = 90°$

$$\frac{\sin \alpha_1}{\sin 90°} = \sin \alpha_1 = \frac{v_1}{v_2}$$

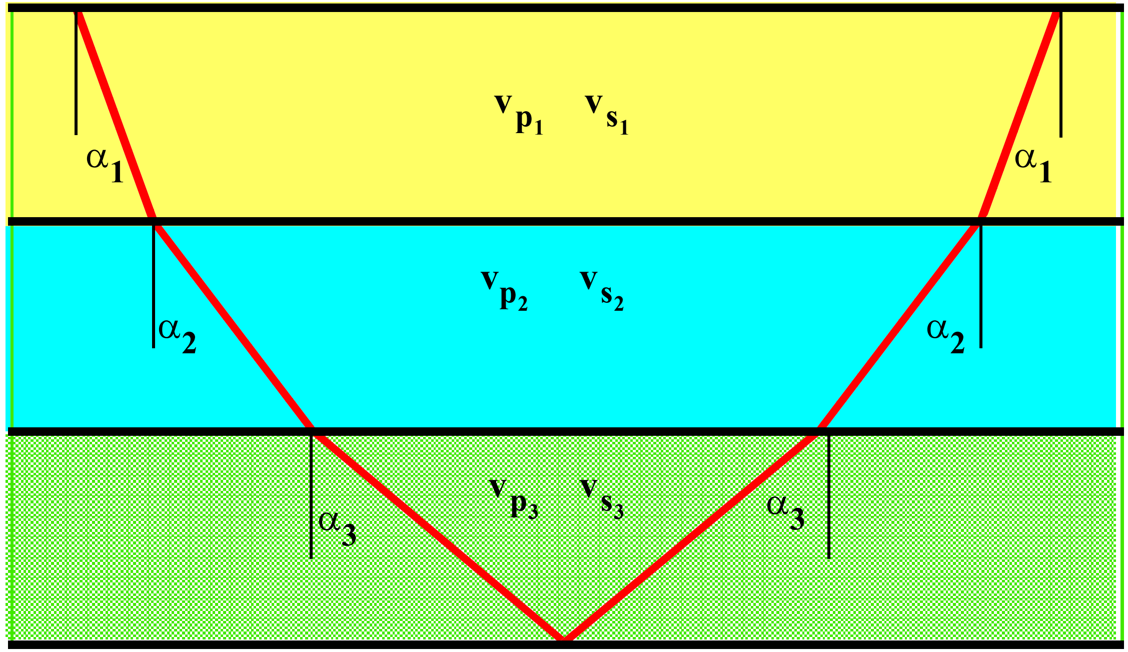
Interface: Conversion from P wave to S wave



$$\frac{\sin\alpha_1}{\sin\beta_1} = \frac{v_{p_1}}{v_{s_1}}$$

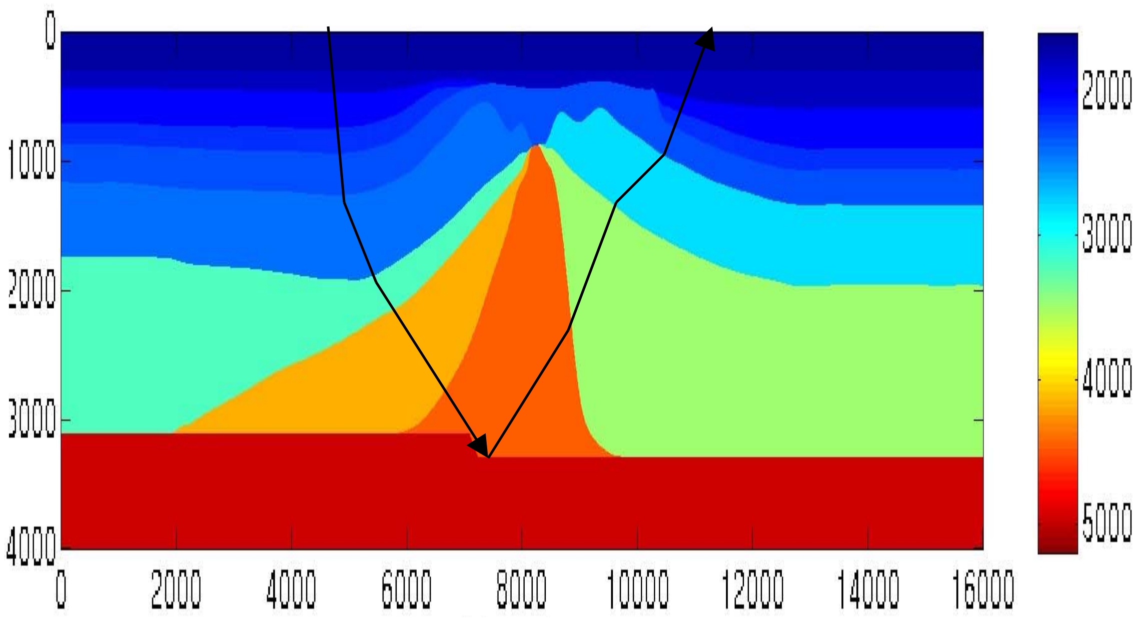
$$\frac{\sin\alpha_1}{\sin\beta_2} = \frac{v_{p_1}}{v_{s_2}}$$

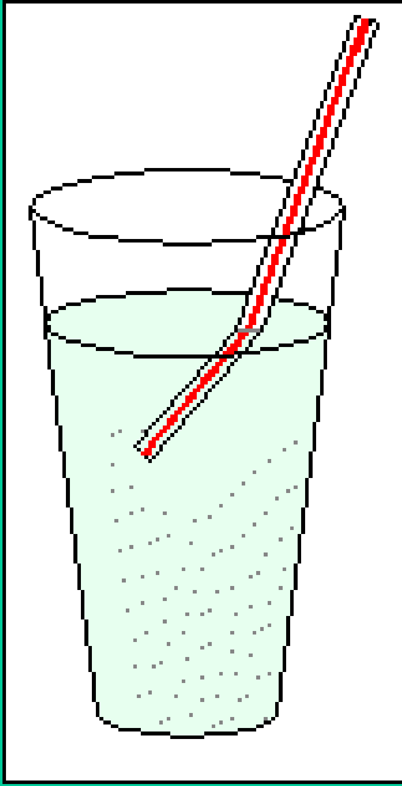
Snell's law



$$\frac{\sin\alpha_1}{v_{p_1}} = \frac{\sin\beta_1}{v_{s_1}} = \frac{\sin\alpha_2}{v_{p_2}} = \frac{\sin\beta_2}{v_{s_2}} = \frac{\sin\beta_n}{v_{s_n}} = p = \text{constant}$$

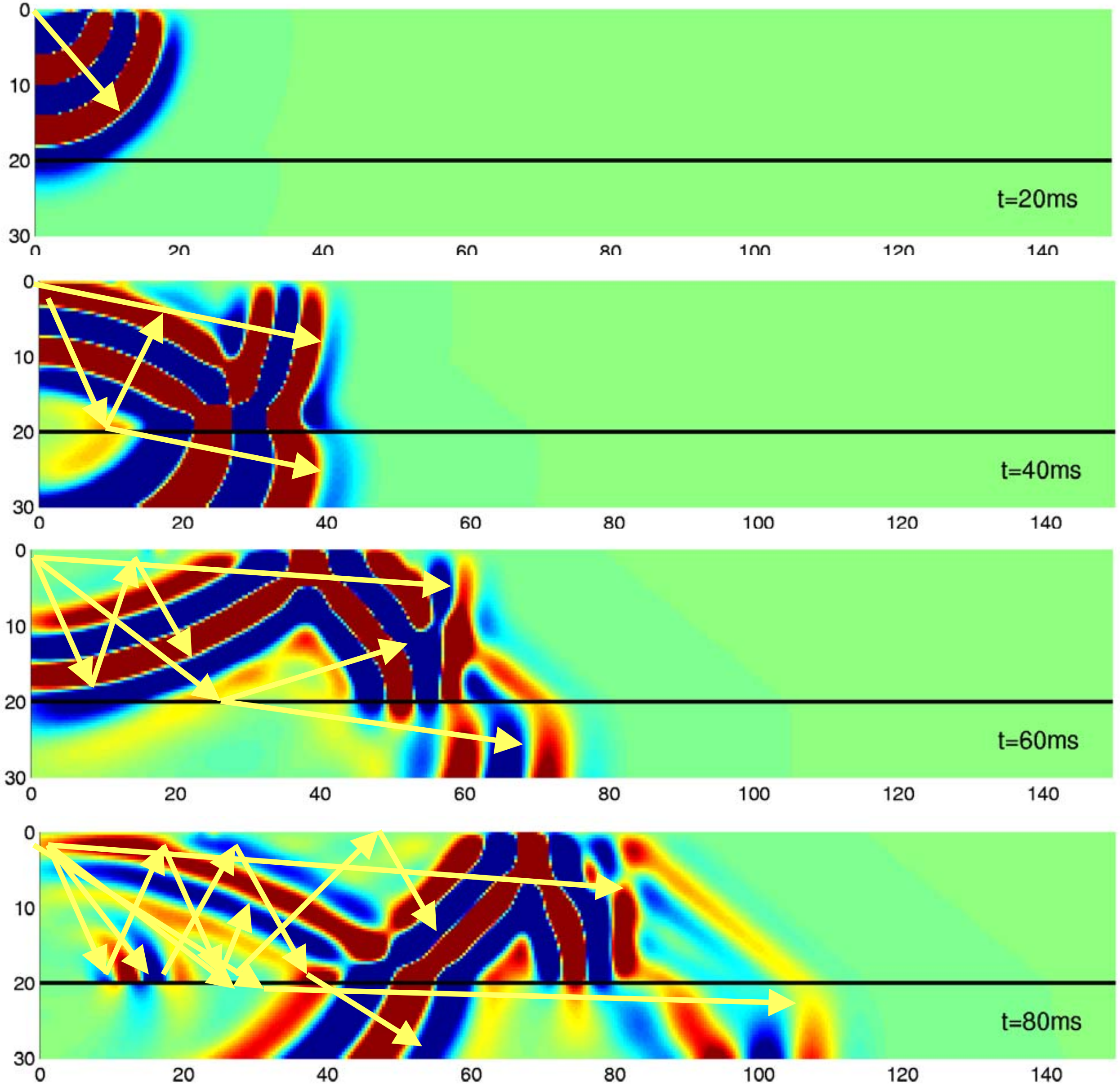
p = Slowness





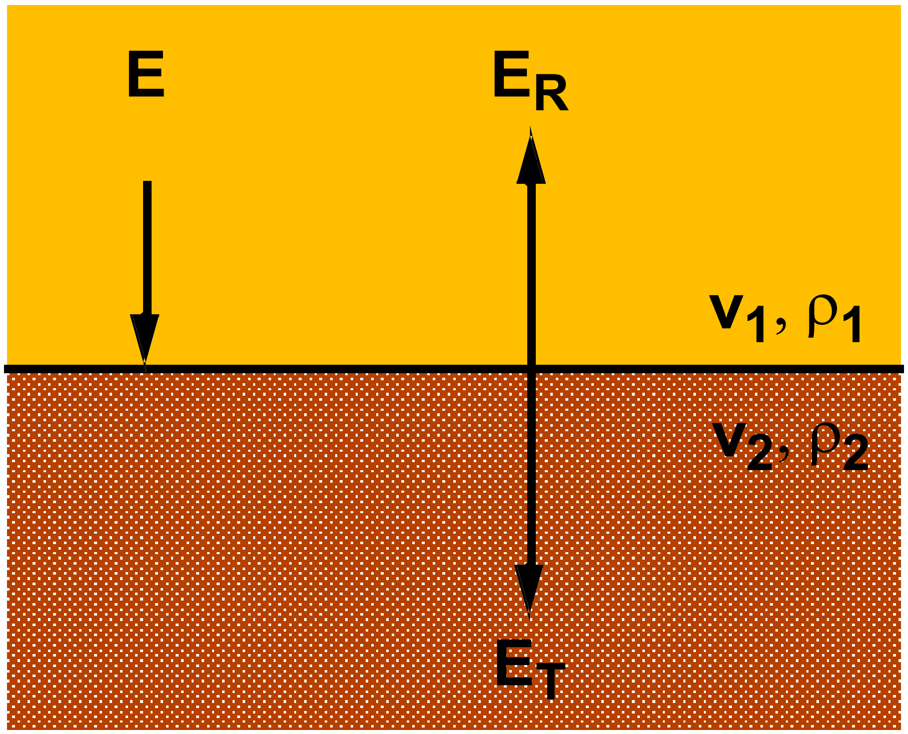
Refraction caused by place dependent
propagation velocity

Propagation of seismic waves



(Roth et al., 1998)

Transmission- and Reflection coefficients



$$E = E_R + E_T$$

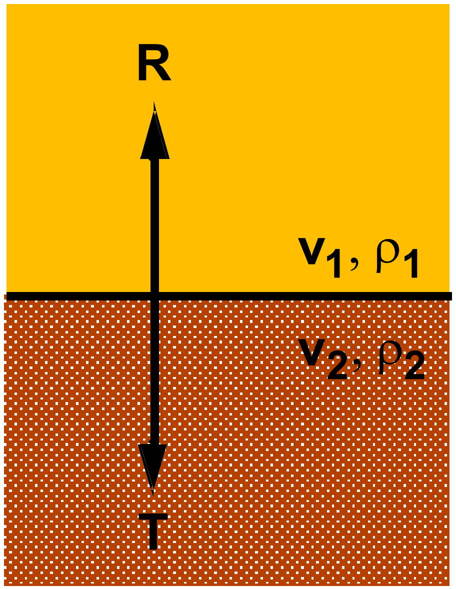
$$R + T = 1$$

E = Energie

R = Reflection coefficient

T = Transmission coefficient

Zoeppritz' equations at normal incidence



Reflection coefficient

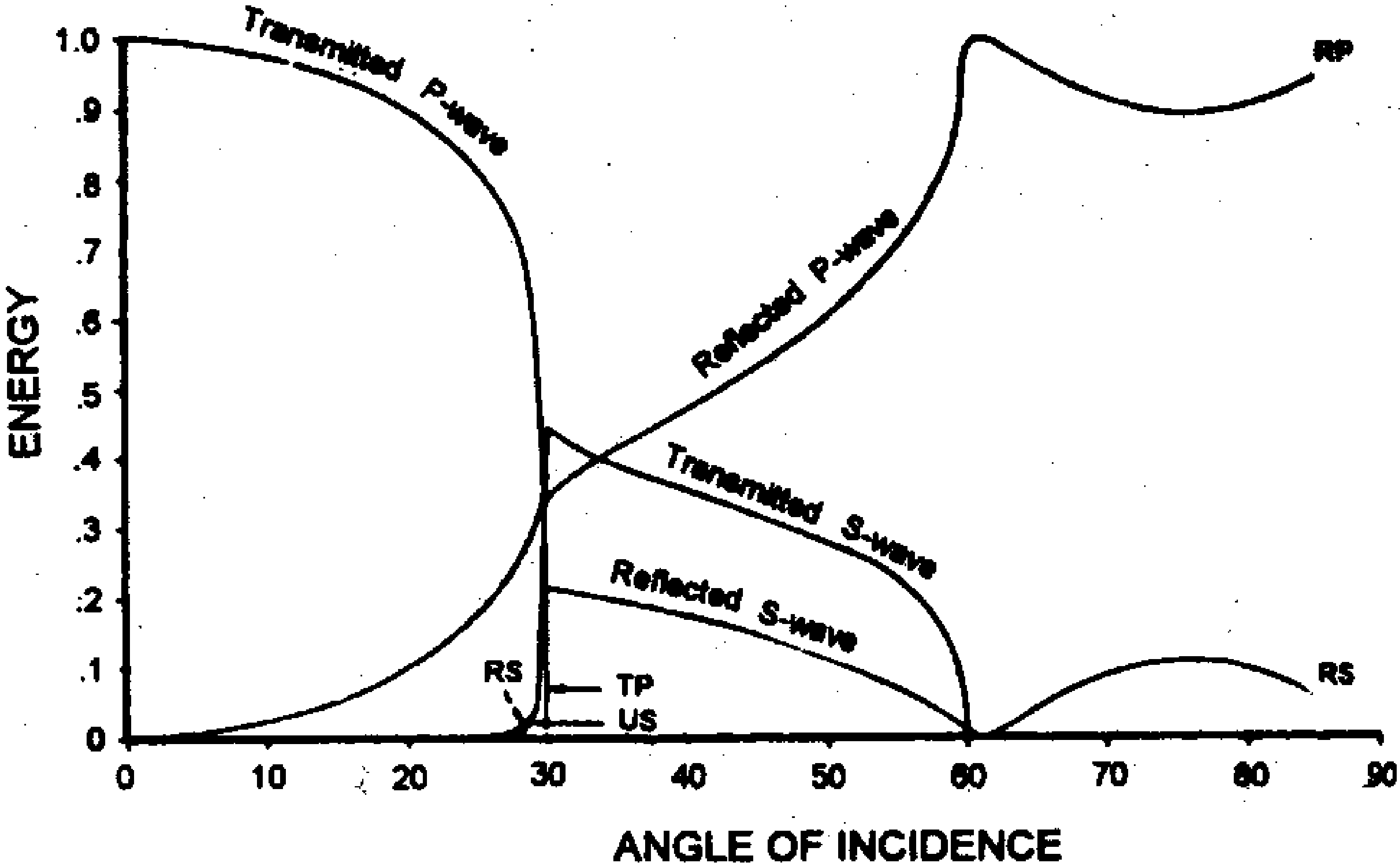
$$R = \frac{v_2\rho_2 - v_1\rho_1}{v_2\rho_2 + v_1\rho_1} = \frac{Z_2 - Z_1}{Z_2 + Z_1}$$

Transmission coefficient

$$T = \frac{2v_1\rho_1}{v_2\rho_2 + v_1\rho_1} = \frac{2Z_1}{Z_2 + Z_1}$$

with $Z = v\rho$ = acoustic Impedance

Angle-dependent reflection- and transmission-coefficients



(Sheriff and Geldart, 1995)