Title: Physics in Nature Presentation: Waves Are Everywhere

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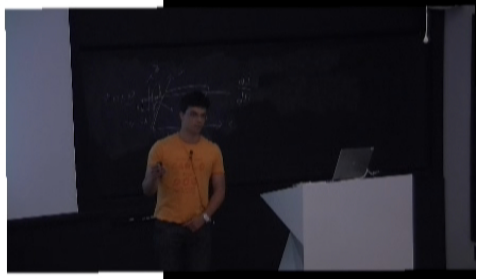
URL: http://pirsa.org/11080117

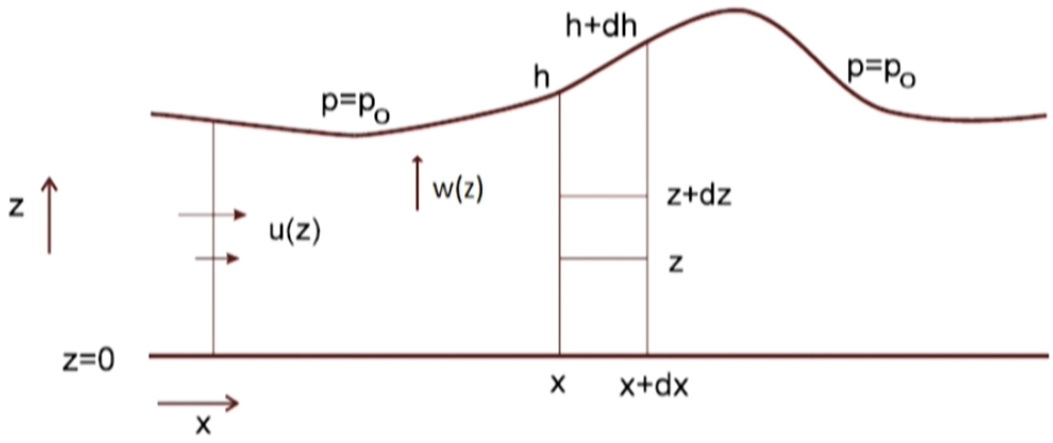
Abstract:

Introduction



- Wave formation
- Shock cone
- Analogous phenomena and some applications

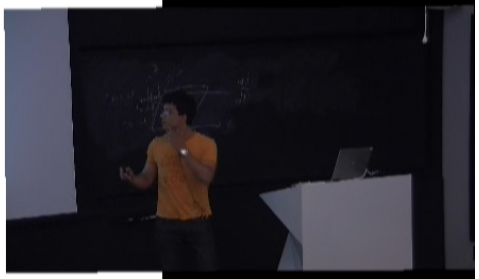
Waves in deep water



- Boundary conditions

$$w(z=0)=0 \qquad \frac{dh}{dt}=w(z=h) \qquad p(z=h)=p_0$$

Waves in deep water

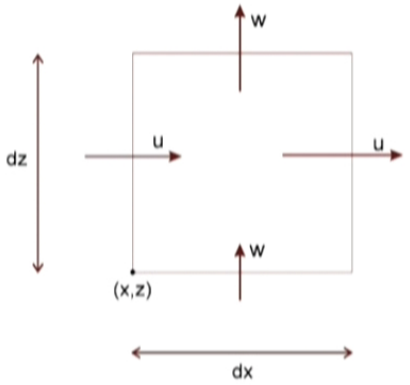


- Momentum equations

$$\rho \frac{du}{dt} = \rho \frac{\partial u}{\partial t} + \rho u \frac{\partial u}{\partial x} + \rho w \frac{\partial u}{\partial z} = -\frac{\partial p}{\partial x}$$

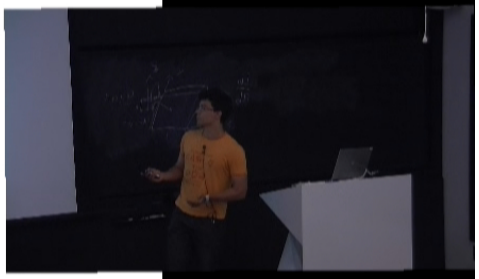
$$\rho \frac{dw}{dt} = \rho \frac{\partial w}{\partial t} + \rho u \frac{\partial w}{\partial x} + \rho w \frac{\partial w}{\partial z} = -\frac{\partial p}{\partial z} - g\rho$$

- Mass conservation



$$\nabla \cdot (u, w) = 0$$

Waves in deep water



- In first order, the momentum equations are

$$\frac{\partial u'}{\partial t}+\frac{1}{\rho}\frac{\partial p'}{\partial x}=0 \qquad \frac{\partial w'}{\partial t}+\frac{1}{\rho}\frac{\partial p'}{\partial z}=0$$

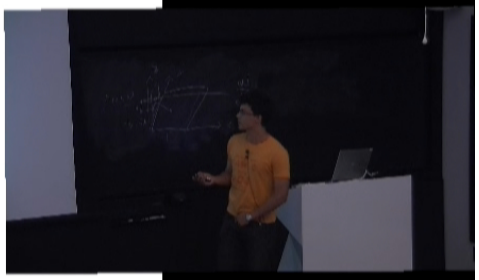
- And using the continuity equation

$$\frac{\partial^2 p'}{\partial x^2}+\frac{\partial^2 p'}{\partial z^2}=0$$

- Resulting

$$p'=\mathrm{Re}\,P(t)e^{ikx}\cosh kz \qquad w'=-\mathrm{Re}\,\frac{k}{\rho}Q(t)e^{ikz}\sinh kz$$

Waves in deep water



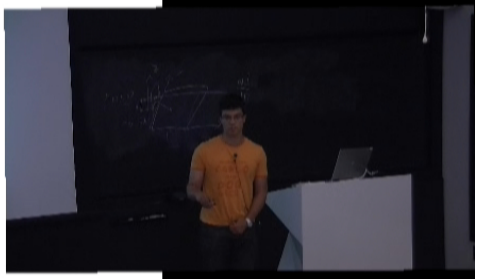
- Using boundary condition

$$\frac{\partial h'}{\partial t} = w' \Rightarrow Q(t) = Q_1 e^{-i\omega t} + Q_2 e^{i\omega t}$$

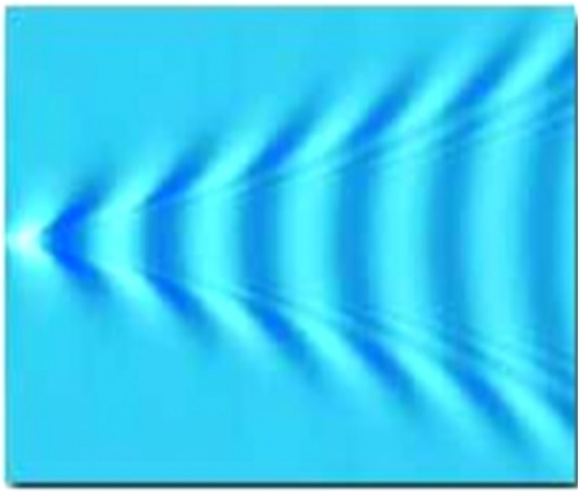
- With $$v = \frac{\omega}{k} = \frac{1}{k}\sqrt{gk \tanh kD} \approx \sqrt{g\frac{\lambda}{2\pi}}$$

- Thus it is wavelength dependent and the group velocity is $$v_g = \frac{d\omega}{dk} = \frac{1}{2}v$$

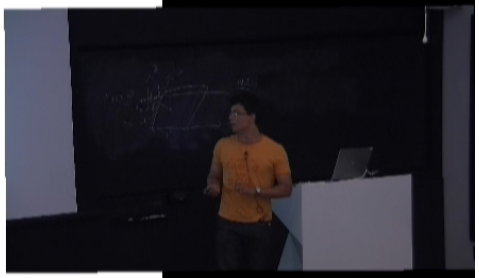
The cone effect



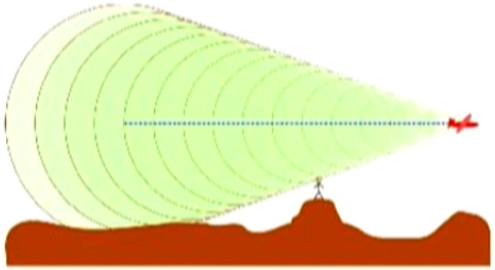
- V shockwave formation.
- Constructive interference of waves with velocity smaller than the object's speed.

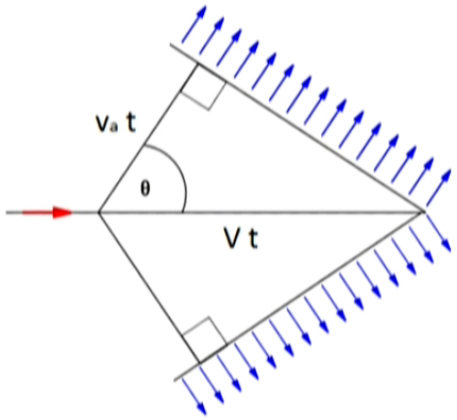


Sound waves

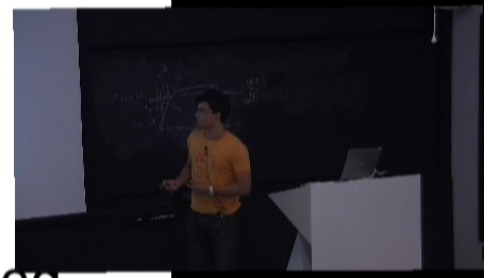


- Analogous effect with the propagation of sound on the air, when an object travels faster than sound.



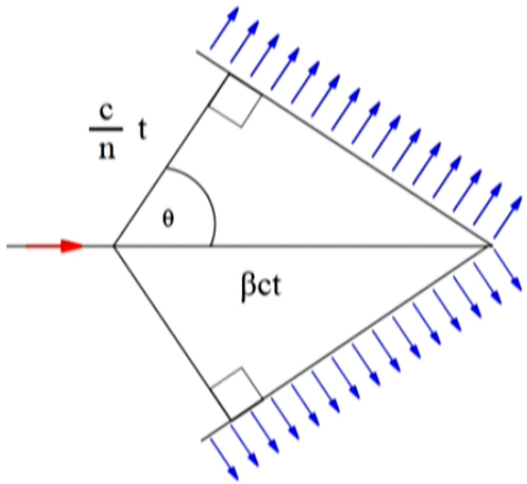


Čerenkov radiation

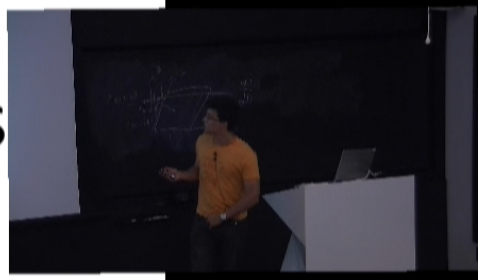


- Čerenkov radiation is emitted when a charged particle passes through a dielectric medium at a speed greater than the phase velocity of light in that medium.

$$\cos\theta = \frac{1}{n\beta}$$

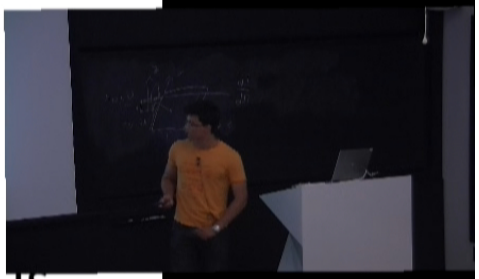


Čerenkov radiation applications



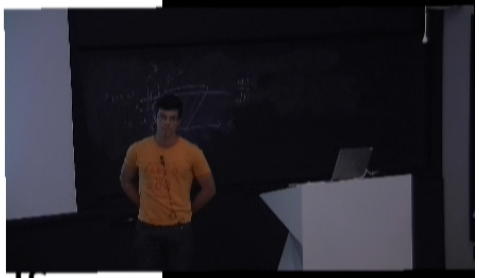
- Astrophysics experiments
- Nuclear reactors
- Particle physics experiments

Conclusion



- Speed of propagation for deep water waves is wavelength dependent, so highly dispersive.
- Cone effect due to interference or objects travelling faster than waves.
- Applications of the effect with Čerenkov radiation.

Conclusion



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