Lecture notes **March 12, 2026**

The emboldened words are crossword puzzle solutions.

Dissertation: https://chiragokani.github.io/research/refs/gokani2026scattering.pdf

Slide 2

- **Symmetry**: "the existence of different viewpoints from which the system appears the same"
    - Objects bearing an axis of symmetry are discussed "to avoid excessive entanglement in the techniques of mathematical analysis" (Ginsberg).
    - For a deeper discussion of symmetry in physics, see the Feynman lecture "Symmetry in Physical Law."
- **Homogeneity**: uniformity of a system at different positions
- **Isotropy**: uniformity of a system in different directions
- **Fresnel**: French physicist who studied the diffraction of light from circular apertures
- **Rayleigh**: British physicist who explained why the sky is blue
    - Rayleigh avoided the issue of asymmetry, stating that "the particles must be supposed to be oriented in all directions indifferently."
- **Gor'kov**: Soviet physicist who calculated acoustic radiation force on subwavelength spheres

Slide 3

- **Helmholtz**: German physicist after whom $\nabla^2 p + k^2 p = 0$ is named
- The density of an **incompressible** medium does not vary time, precluding the existence of acoustic waves.
- The zero-frequency limit of acoustics reduces to linearized incompressible flow.
    - For a discussion of static phenomena governed by the Laplace equation, see Feynman's "Electrostatic Analogs."
- The **quasistatic** approximation, also called the low-frequency approximation, assumes that the acoustic wavelength is much larger than the length scale of interest.
- At high frequencies, wavefronts are **quasiplanar**, meaning that they resemble plane waves.
- **Geometric** acoustics is an infinite-frequency approximation in which sound waves are modeled as rays.
- For a mathematical treatment of the various limits discussed on this slide, see Sec. A.1 of my dissertation.
- For alternative perspectives on the parameter ka, see Sec. A.2.

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- **Quadratic**: This is the order of the wave variable at which radiation force is studied.

    - See App. B of my dissertation for two independent derivations of acoustic radiation force.

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- **Born**: Physicist after whom the weak-scattering approximation is named; Oppenheimer's advisor

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- **Westervelt**: Physicist associated with the far-field integral for radiation force.
- See Sec. B.4 for a derivation of Westervelt's integral. See van de Hulst's Chap. 1 for a qualitative derivation.

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- Acoustic **polarizability** is denoted by the Greek letter α and describes a scatterer at low frequencies.
    - For a recent review of acoustic polarizability, see Sec. 2.2 of AJ Lawrence's dissertation.

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- For an example of a tensor-valued dipolar polarizability, see Sec. C.6 of my dissertation, in which I calculate radiation forces on rigid spheroids.

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- **Piezoelectric** crystals generate an electric field when squeezed.

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- In a **reciprocal** medium, changing the position of the source and observer has no effect on the measured fields.

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- A **passive** medium does not supply external mechanical or electromagnetic energy and is described by $\boldsymbol{\nabla} \cdot (\mathbf{i} + \mathbf{I}) \leq 0$.

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- The **orbital** number ℓ describes the helicity of a vortex beam.

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- For a derivation of the paraxial equation, see Sec. A.1 of my dissertation.
- For a derivation of the Fresnel diffraction integral, see Sec. E.2 of my dissertation.
- The symbol $\nabla^2_\perp$ is the transverse **Laplacian**, given in Cartesian coordinates by $\partial^2/\partial x^2 + \partial^2/\partial y^2$.