Goldstone's theorem:

A system with a continuous symmetry which is spontaneously broken will have one massless, scalar particle excitation for each generator of the broken symmetry. The corresponding Nambu-Goldstone mode is a long-wavelength plane wave of that generator applied to a ground state.

Massive scalar particle

mode with \( \omega \to 0 \) as \( k \to 0 \)

Phonons in Liquids = Galilean invariance(?)

Phonons in Crystals = Phonons, translation invariance

Spin waves in Magnets = Rotation invariance

Second sound in Superfluids = Gauge invariance (heat waves)

Mechanism

Higgs Boson: Gauge field coupling violates Goldstone (same as Superconductor's Anderson-Higgs mechanism.) (Higgs predicted boson.)
Crystals violate Goldstone's 'theorem' too!

Rotational symmetry spontaneously broken

Plane wave
Rotation of crystal lattice not low energy!

Rotate slabs Tear apart/smash together

Vague analogy:
Supercconductors \( \Psi e^{i\phi} \)
\( \leftrightarrow \) Rotations
Supercconductor gauge field \( A \)
\( \leftrightarrow \) Phonons

Higgs mechanism: Rotations couple to phonons, "gain a mass!"