Condensed Matter Physics
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Lecture - 14
Lattice Vibrations (Continued)
Phonon Thermal Conductivity – Worked Examples

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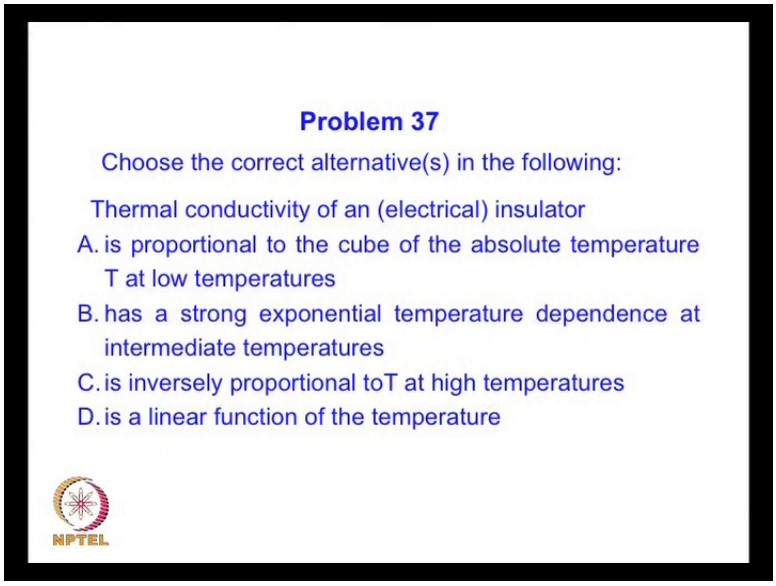

Next we are talking about thermal conductivity of an electrical insulating material, insulator or dielectric material. Now which are the alternatives is correct is proportional to the cube of the absolute temperature T at low temperatures which is obviously correct. Has a strong exponential temperature dependence at intermediate temperatures, this is because of the Umklapp process, this also correct. And it is inversely proportional to T at high temperatures, which is also correct. But it is not linear function of the temperature. So the correct alternatives are a, b and c.

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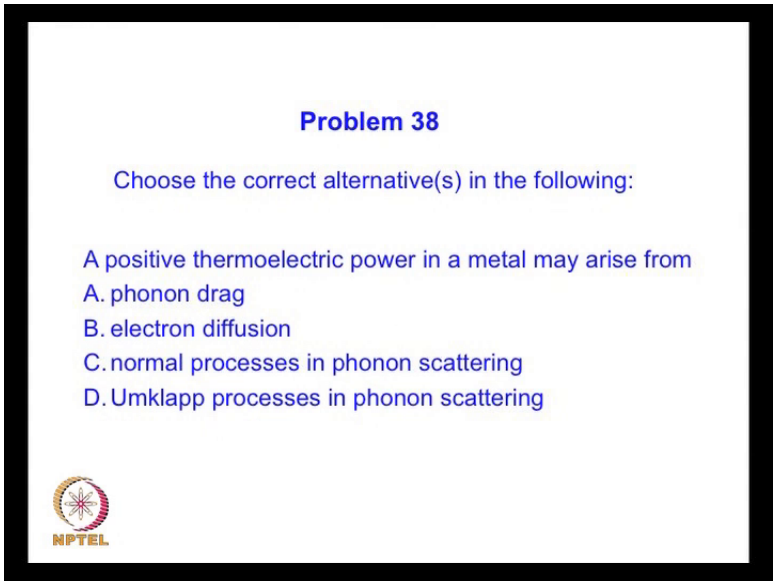

Then the next question statement is about positive thermo power.

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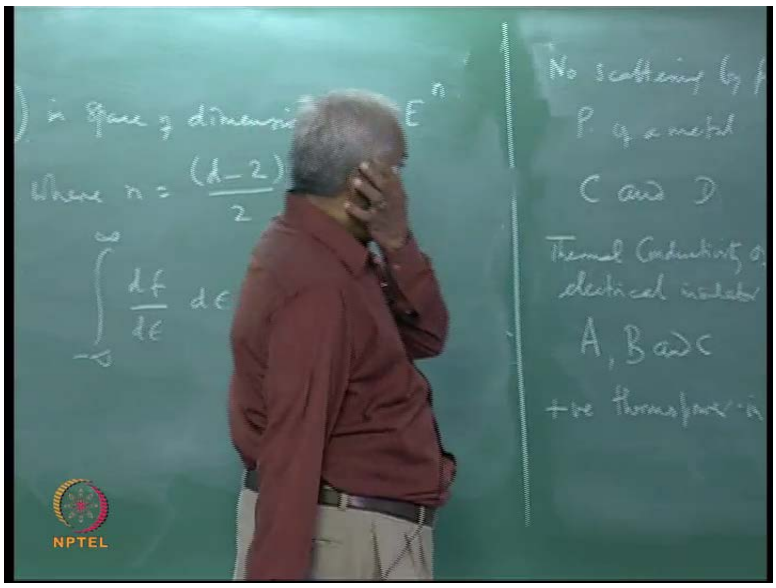

Usually if it is a metal, in a metal, we know the thermo power has a negative sign. So the only way this can become positive is because of Umklapp which can reverse the phonon wave vector. So obviously the phonon, the alternative d is obviously correct that means alternative a about phonon drag is also correct. So the correct alternatives area and d.

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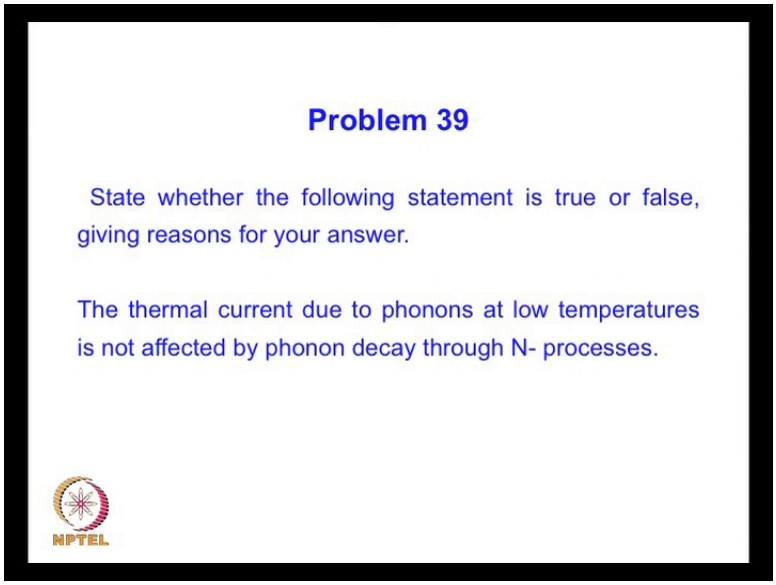

Next we are given the statement and ask to check whether it is true or false. And we are ask to justify the answer.

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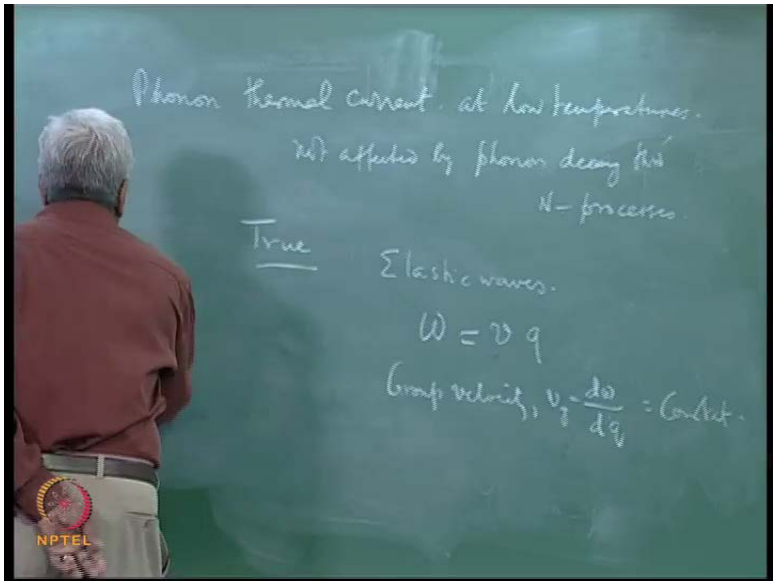

So the thermal current due to phonons at low temperatures, the statement is that this is not affected by phonon decay, not affected by phonon decay through normal N processes.

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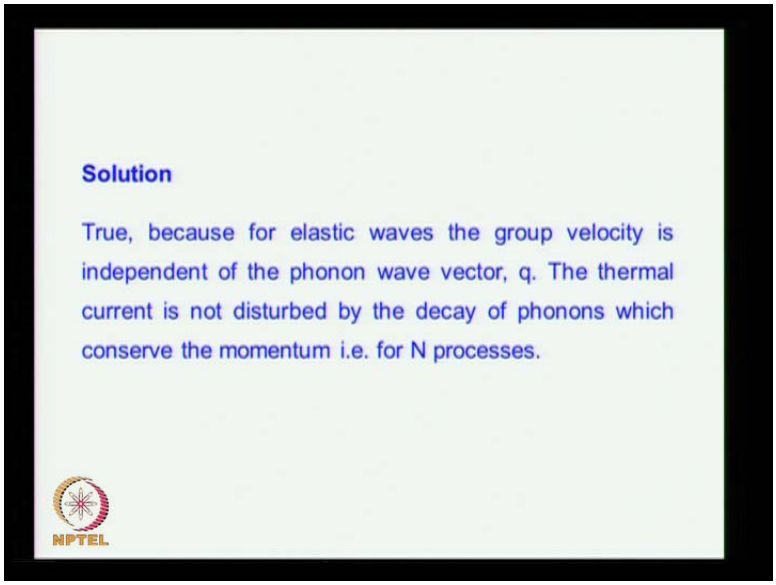

So this is the statement and we are ask whether this is correct or not. The statement is true. The reason for this is, if we have elastic waves, phonons are nothing but excitation of elastic waves, and therefore, the group velocity omega, the dispersion relation is omega equal to v q, where q is phonon wave vector, v is the speed of sound. So the group velocity v g which is d omega by d k, d q in this case is constant. So phonon have a constant group velocity, so the thermal conduction is mainly determined by the group velocity of the phonon. Therefore, the thermal current is not disturbed by the decay of phonon, which conserve the momentum, because the group velocity is constant.

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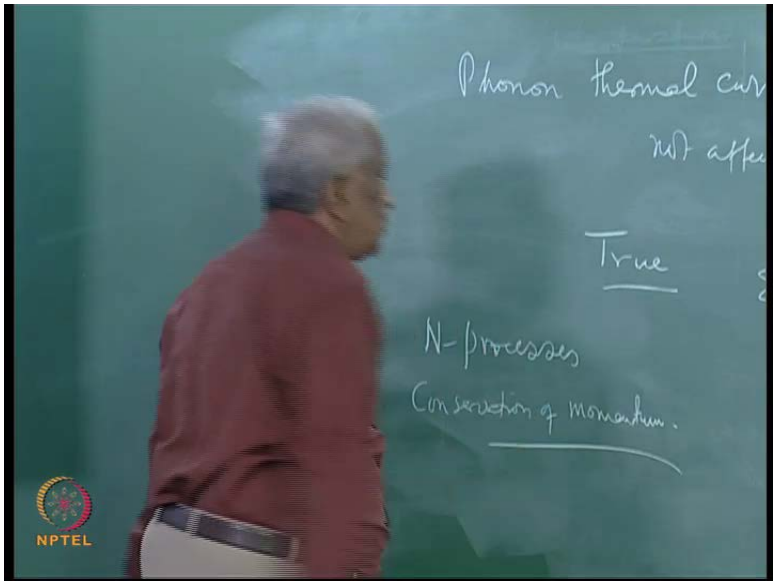

Therefore, processes – N-processes are one in which momentum is conserved, it is only the u processes in which the momentum is not conserved. So when the momentum is conserved that is consistent with the group velocity being constant, therefore such processes do not affect the thermal current. So the statement is correct.