Notes 4

Tuesday, September 21, 2010
11:10 PM

Evanescent Modes in Band Gaps

What is an evanescent wave?

$e^{j(\omega t + k \cdot r)}$ $\Rightarrow$ propogating wave

what makes this prop?

magnitude of $e^{jx} = 1$ regardless of x

change in phase only

What if k is complex?

complex direction? Doesn't make sense

$e^{j(k_r + jk_i) \cdot r} = e^{jk_r \cdot x} e^{-k_i r}$

$e^{-k_i r}$ $\Rightarrow$ exponential decay. Here we have a wave that is traveling but getting smaller as it moves.

side note

this is how we quantify loss & gain in materials

complex $\epsilon_r = \epsilon_r' + j\epsilon_r''$

A few features of evanescent fields

1) they can do no work

2) the E & H fields are out of phase w/ each other

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3] No energy is transferred to them
everything in comes out

$\boxed{\text{Goos-Hanchen shift}}$

What happens if you excite/direct
a wave w/ wavelength in the gap?

We know it will reflect off but
what happens in the crystal?

Excite evanescent mode into the crystal

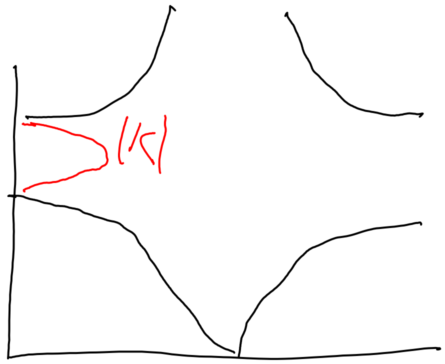
$$H(r) = e^{jkz} u(z) e^{-Kz}$$

$$k \Rightarrow k + jK$$

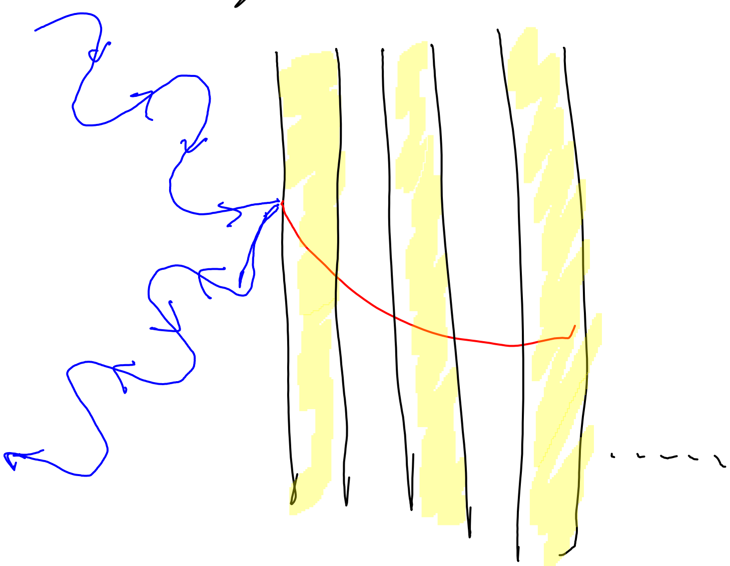
in the bandgap solutions with
$k = 0$ $K \neq 0$ are valid & can be found.

This mode decays at the rate of $1/K$ into
the crystal

In general K starts small at the band
edge and grows to a maximum @ the
middle of the band



so modes near the band edge decay slower than those at the middle



Evanescent modes only exist at the area where they are excited, they do not propagate through the crystal. As such they are called "localized states"

we can excite them in areas w/ defects, on the surface or by embedding sources in the crystal

Surface States

Local states that exist on the surface of a crystal. Diagram above.

The incident wave cannot propagate in the crystal, but it does excite a local mode on the surface

The excited mode can either

1) have a component that propagates in air
   this will cause reflection

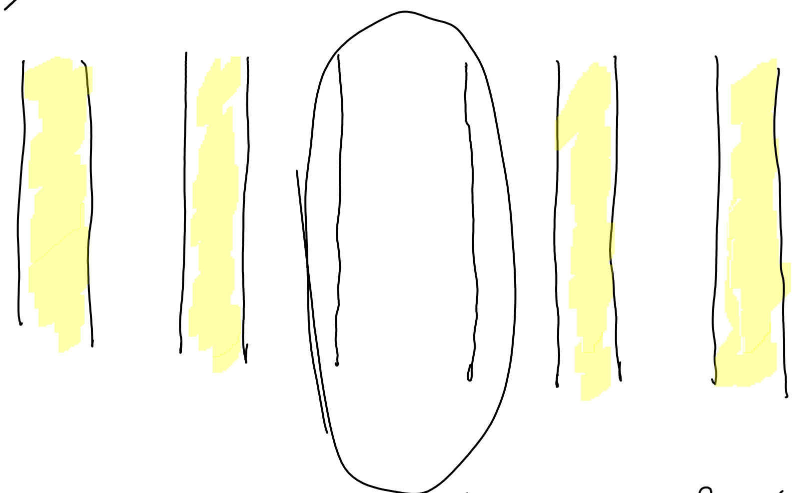
2) be evanescent in the air as well
   This is called a surface state as all of the light is confined to the surface

These surface states can be coupled into from either outside or inside the crystal and have been used in a variety of applications

HW

Localized Modes at Defects

what happens if we break the periodicity in a small region of the crystal?



the band gap on either side of the defect prohibits some ω but the region in the middle will support those ω.

This looks like two mirrors facing each other

this is a resonant cavity!!

but remember we still have decay on either side of the gap.

The introduction of a defect will affect the band diagram of the uniform crystal slightly.

In general, removing a fraction will

pull modes from the upper band into the bandgap

Increasing the ϵ_r will pull freq. from the lower band up into the gap

As we look @ 2D crystals we will see different defect types.