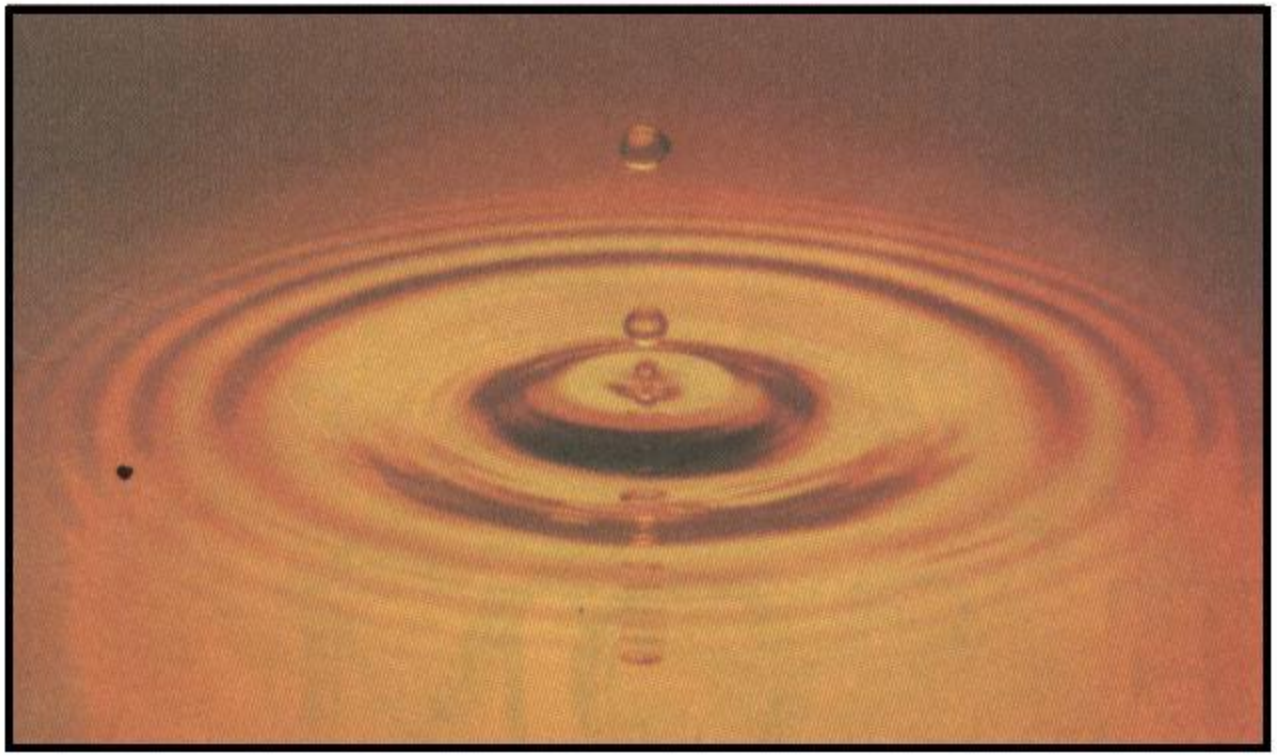
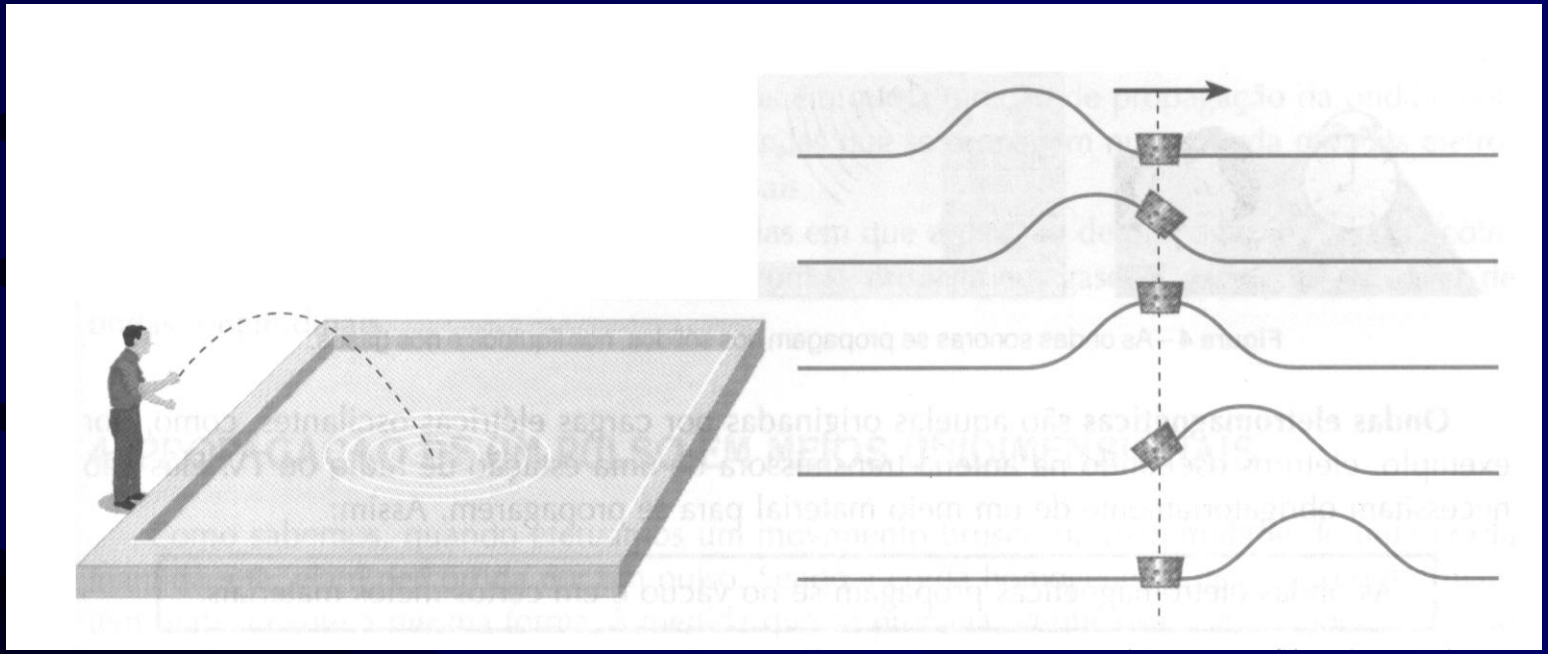
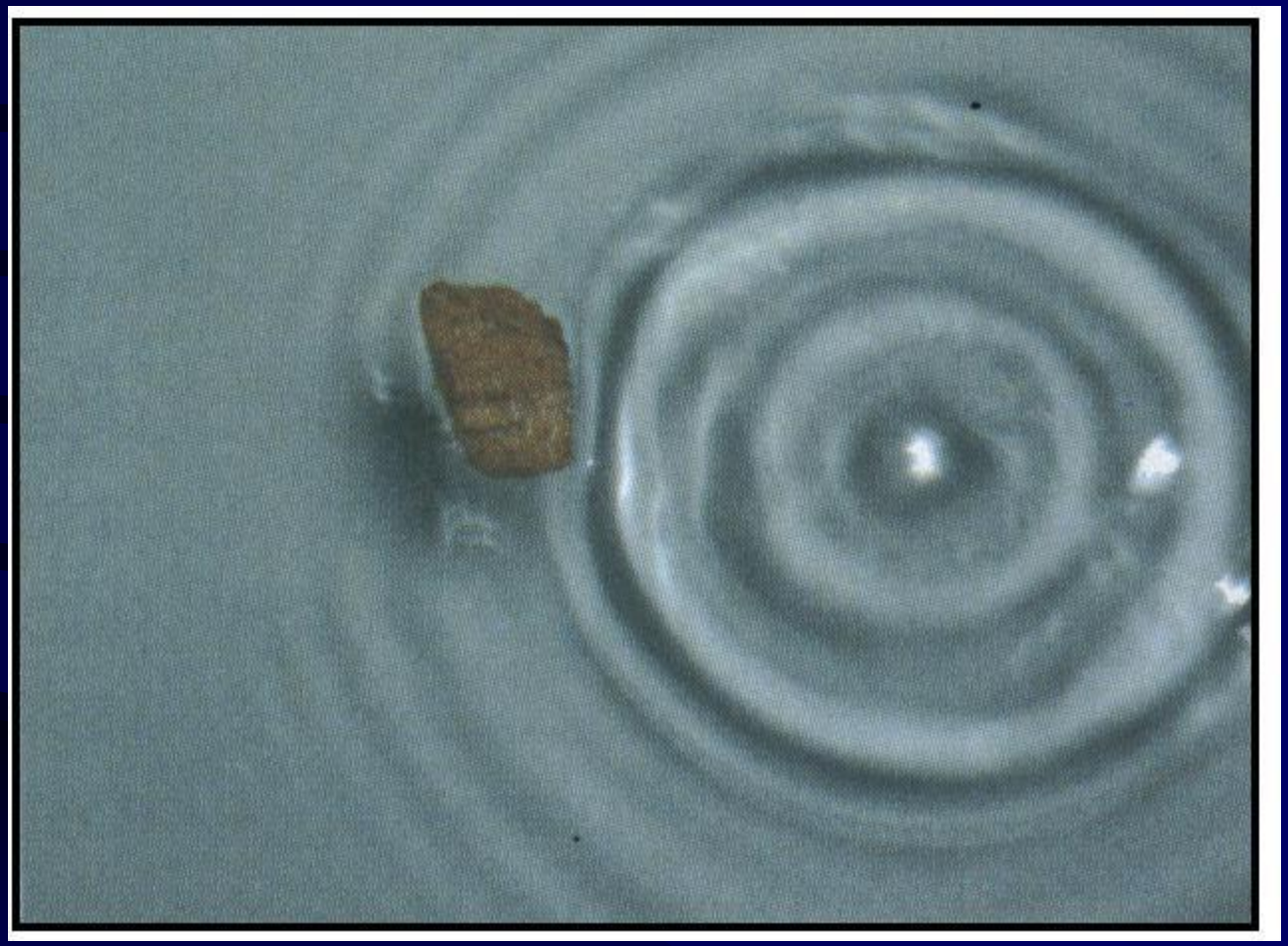
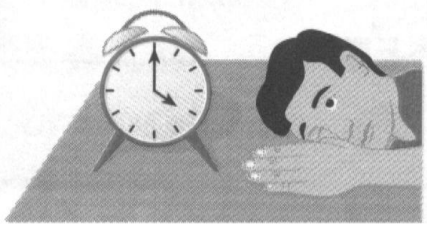
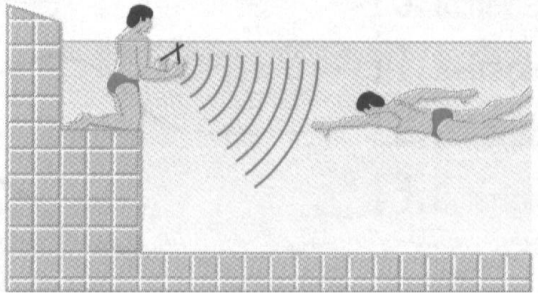
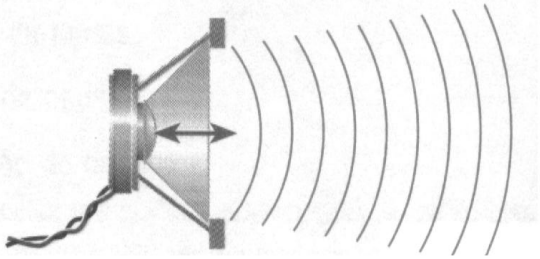




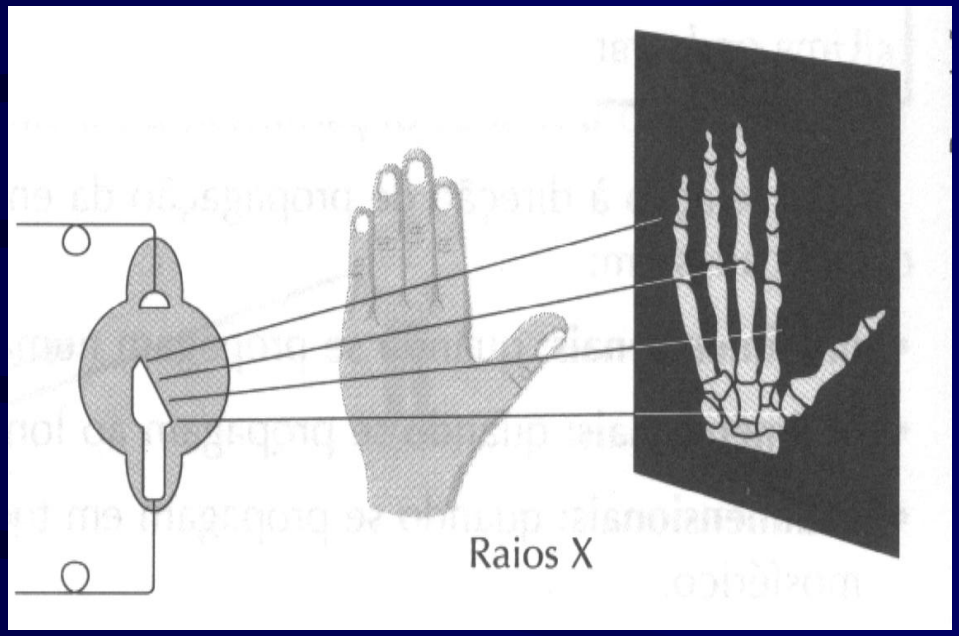


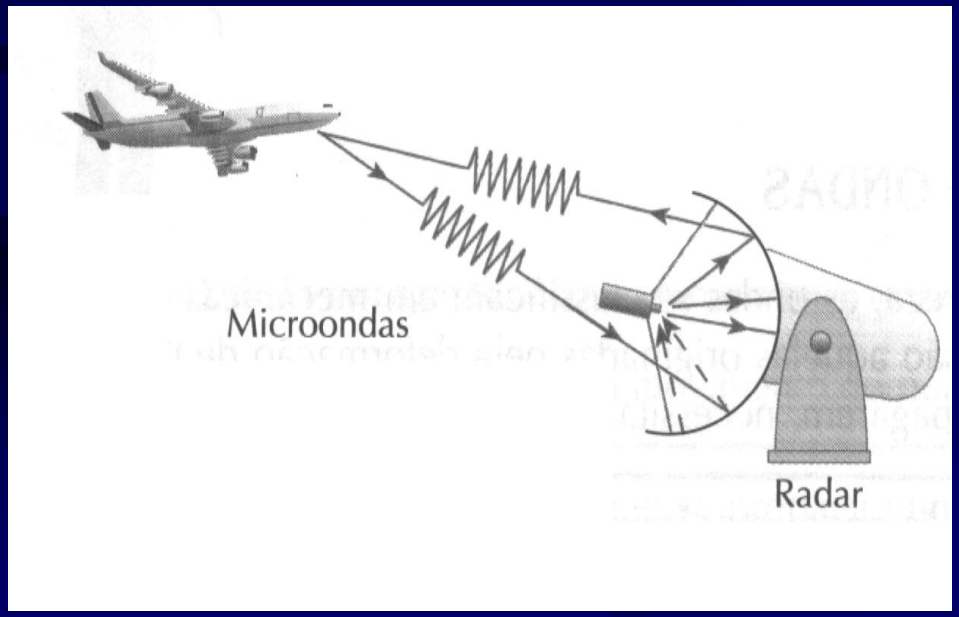


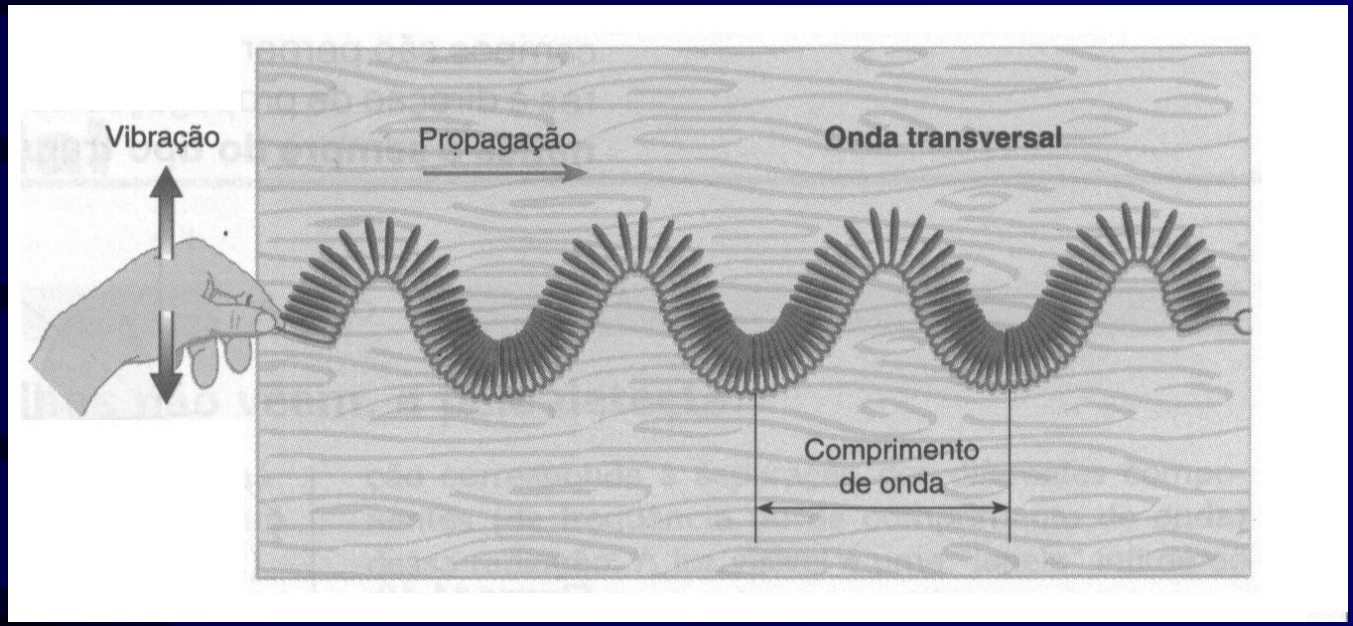


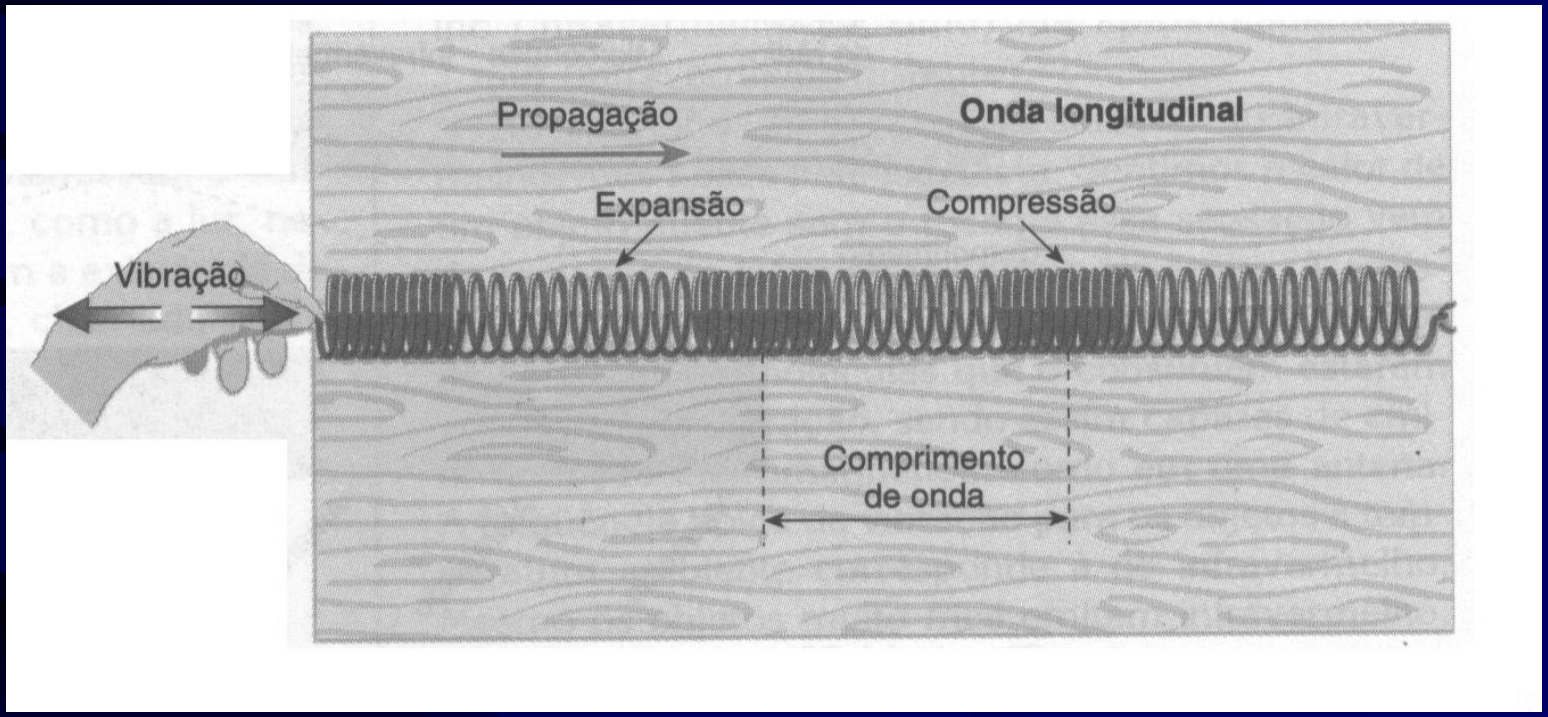


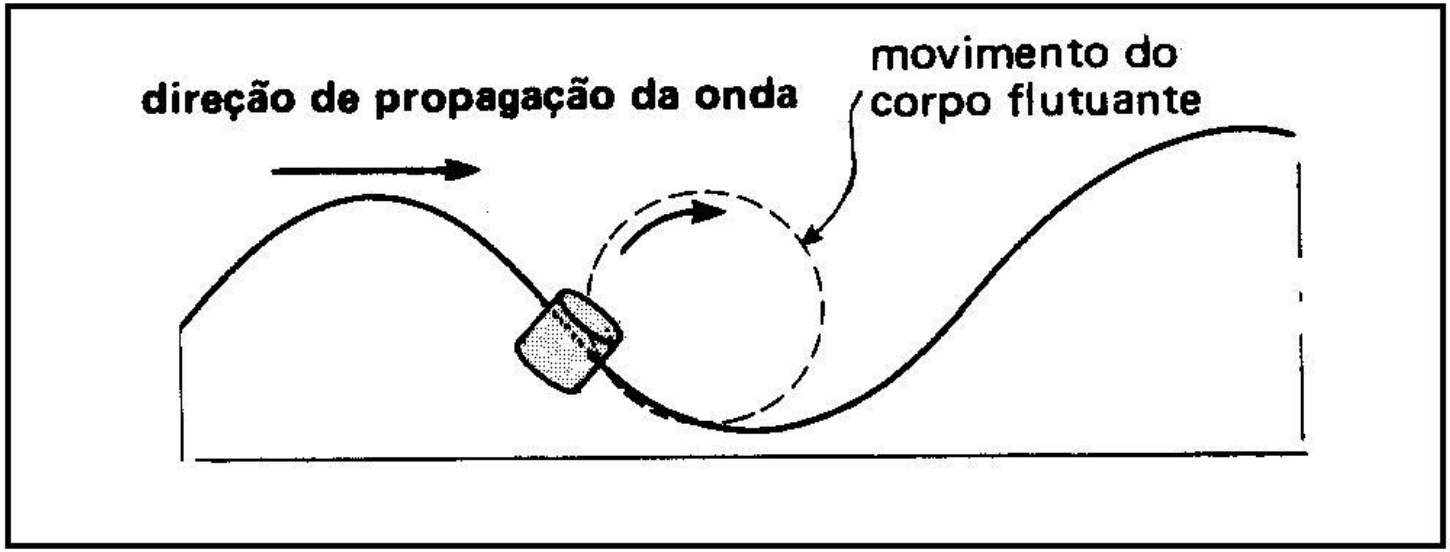
As ondas sonoras são ondas mecânicas

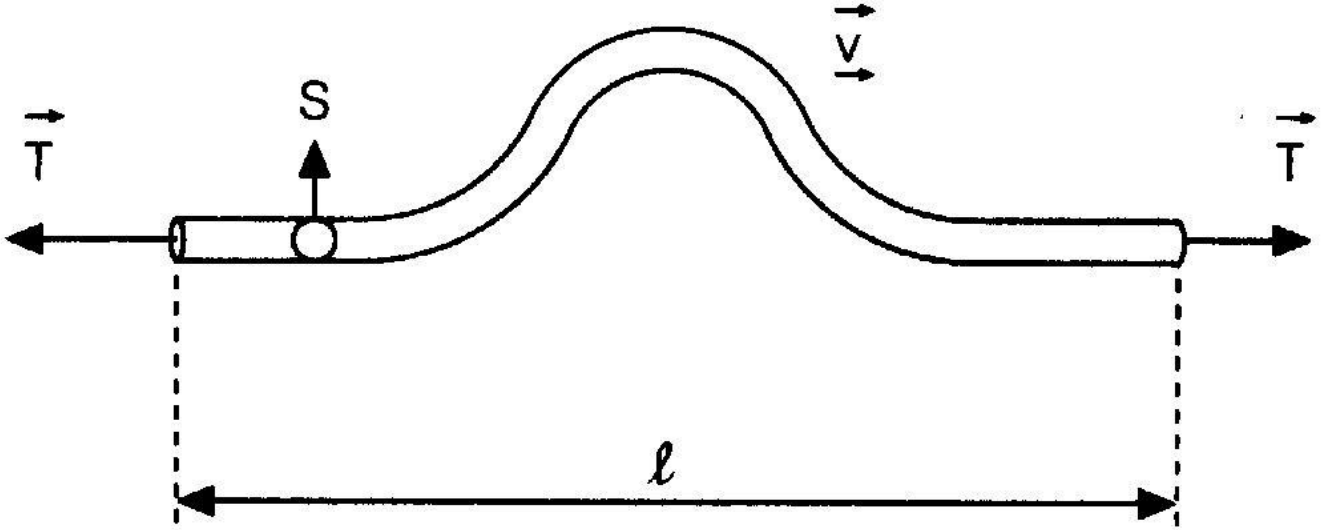

Raios X

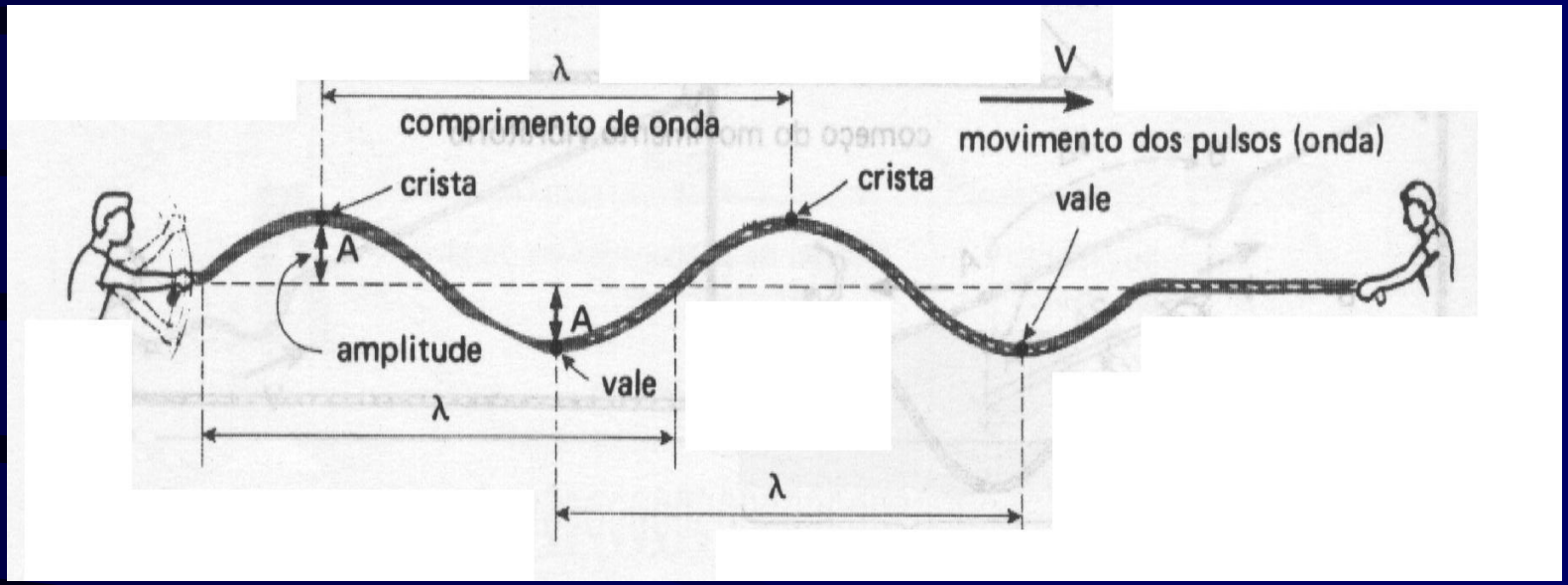

Microondas
Radar

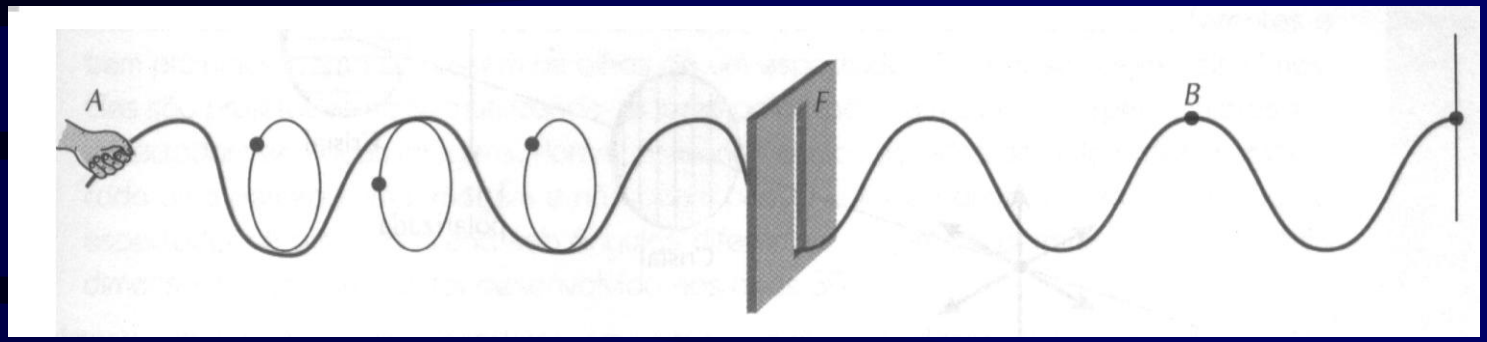

Vibração
Propagação
Onda transversal
Comprimento
de onda

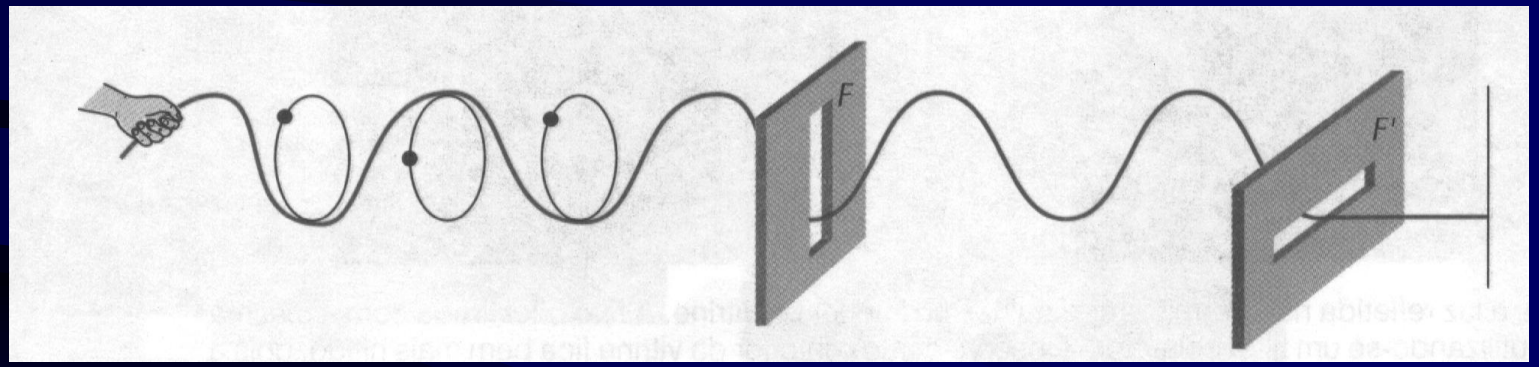

Propagação
Onda longitudinal
Expansão
Compressão
Vibração
Comprimento
de onda

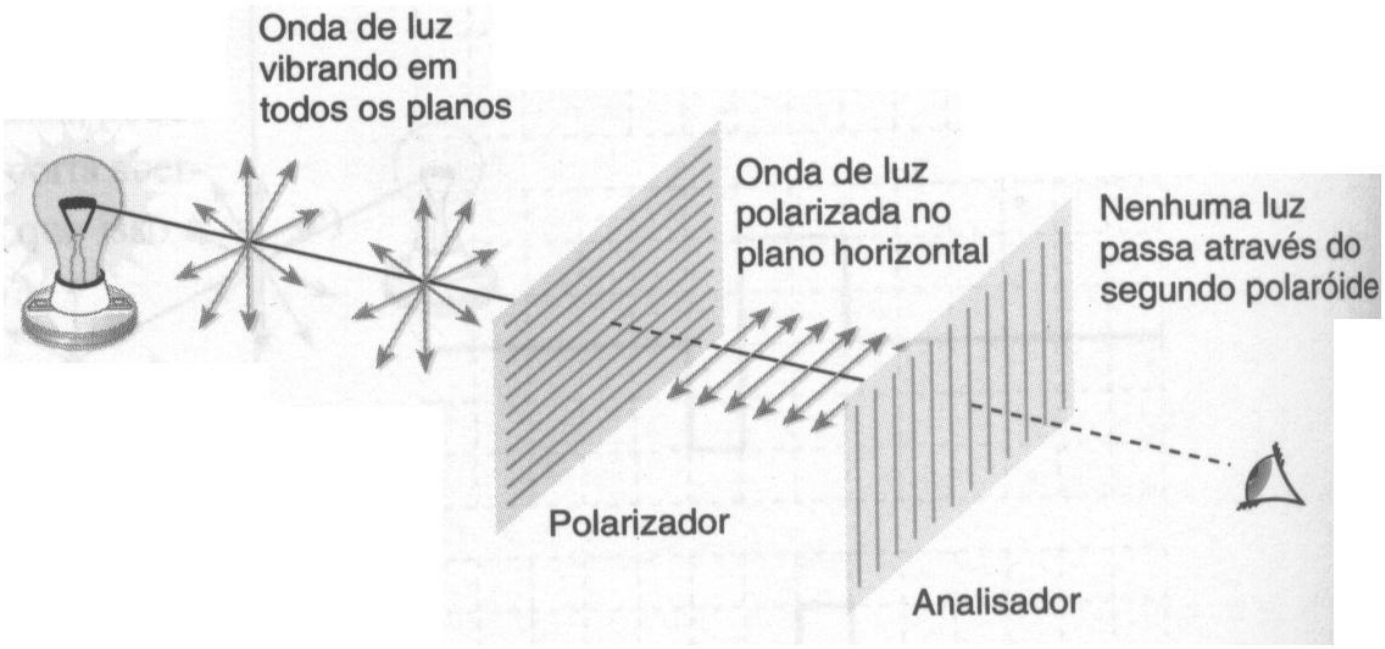

direção de propagação da onda
movimento do
corpo flutuante

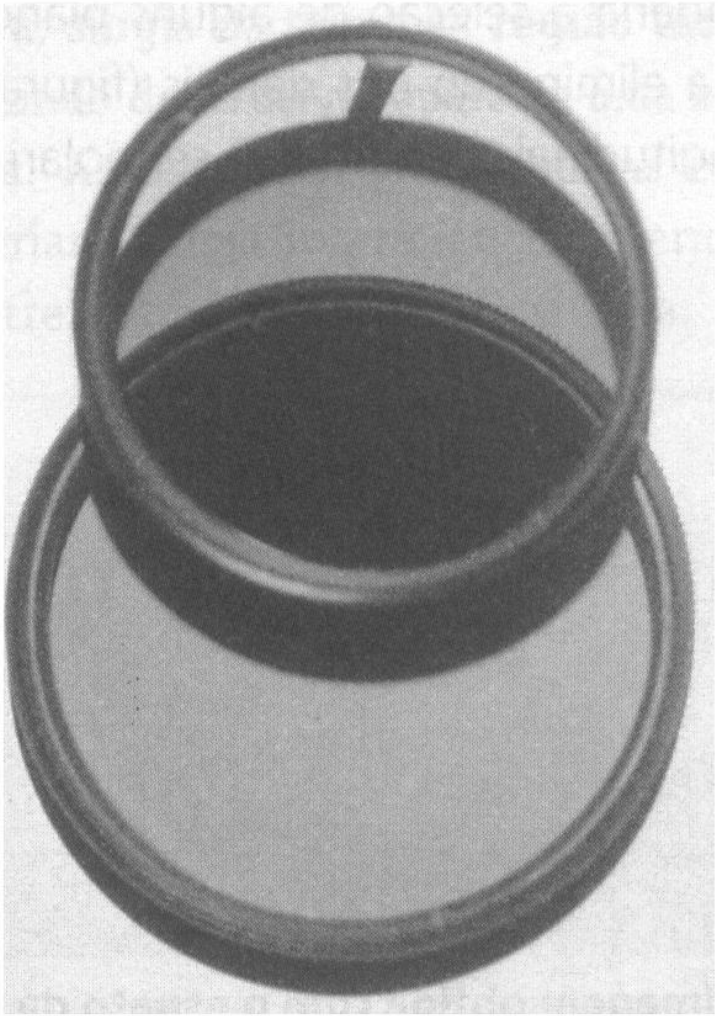

$\vec{V}$
S
$\vec{T}$
$\vec{T}$
ℓ

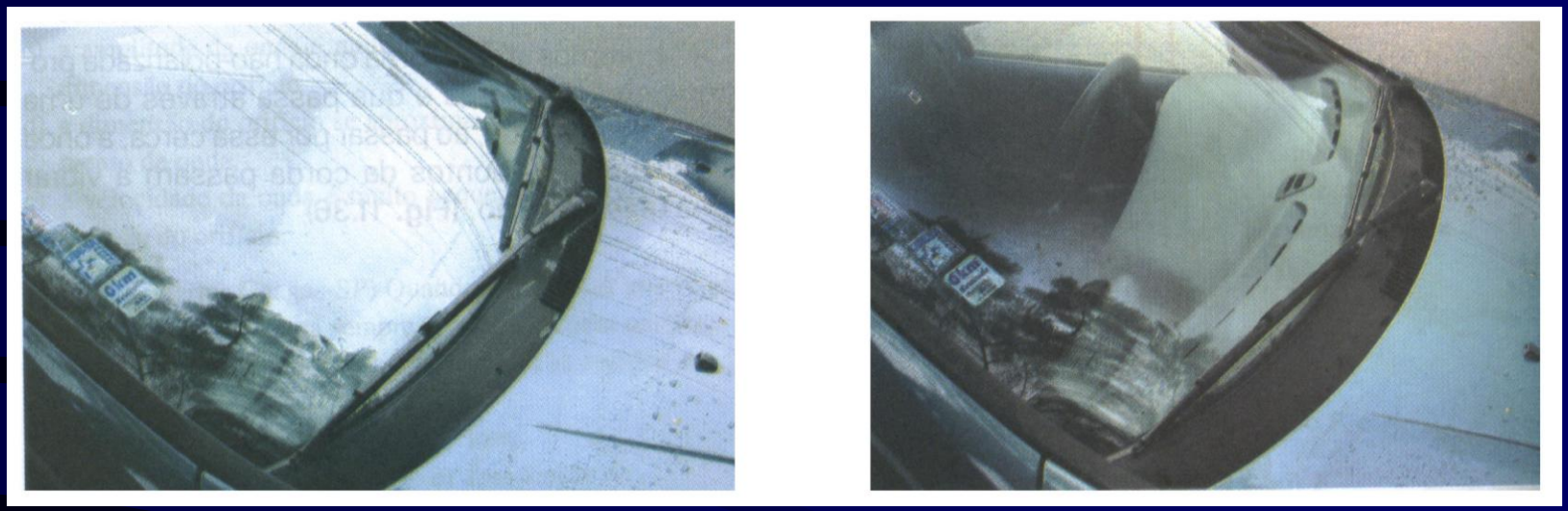

λ
comprimento de onda
V
movimento dos pulsos (onda)
crista
crista
vale
A
A
amplitude
vale
λ
λ

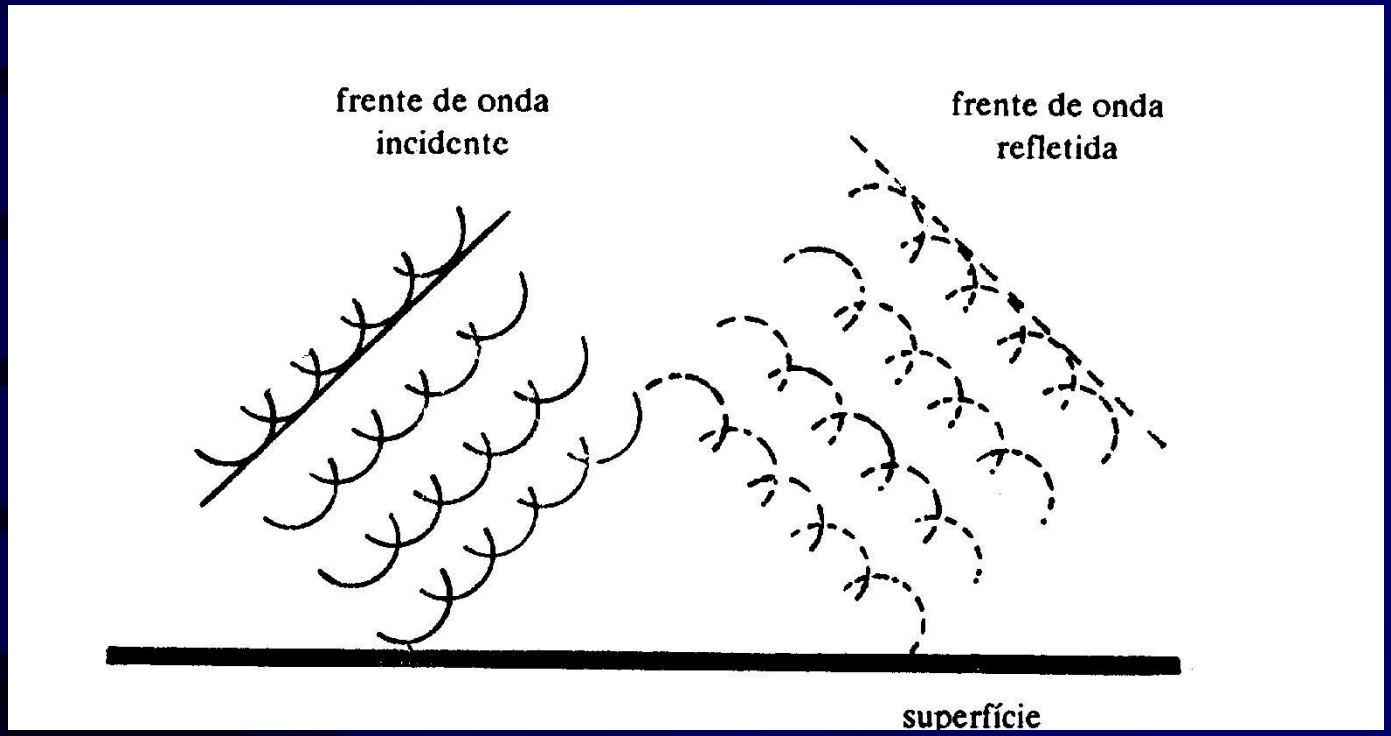

A
F
B

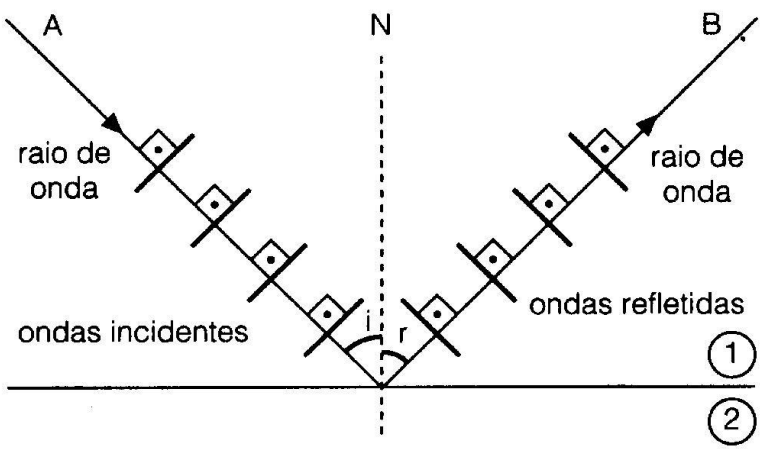

F
F'


Onda de luz
vibrando em
todos os planos
Onda de luz
polarizada no
plano horizontal
Nenhuma luz
passa através do
segundo polaróide
Polarizador
Analisador






frente de onda
incidente
frente de onda
refletida
superfície



Em que:
AI = raio de onda incidente
IB = raio de onda refletido
NI = normal ao ponto de incidência
i = ângulo de incidência
r = ângulo de reflexão

Leis da reflexão

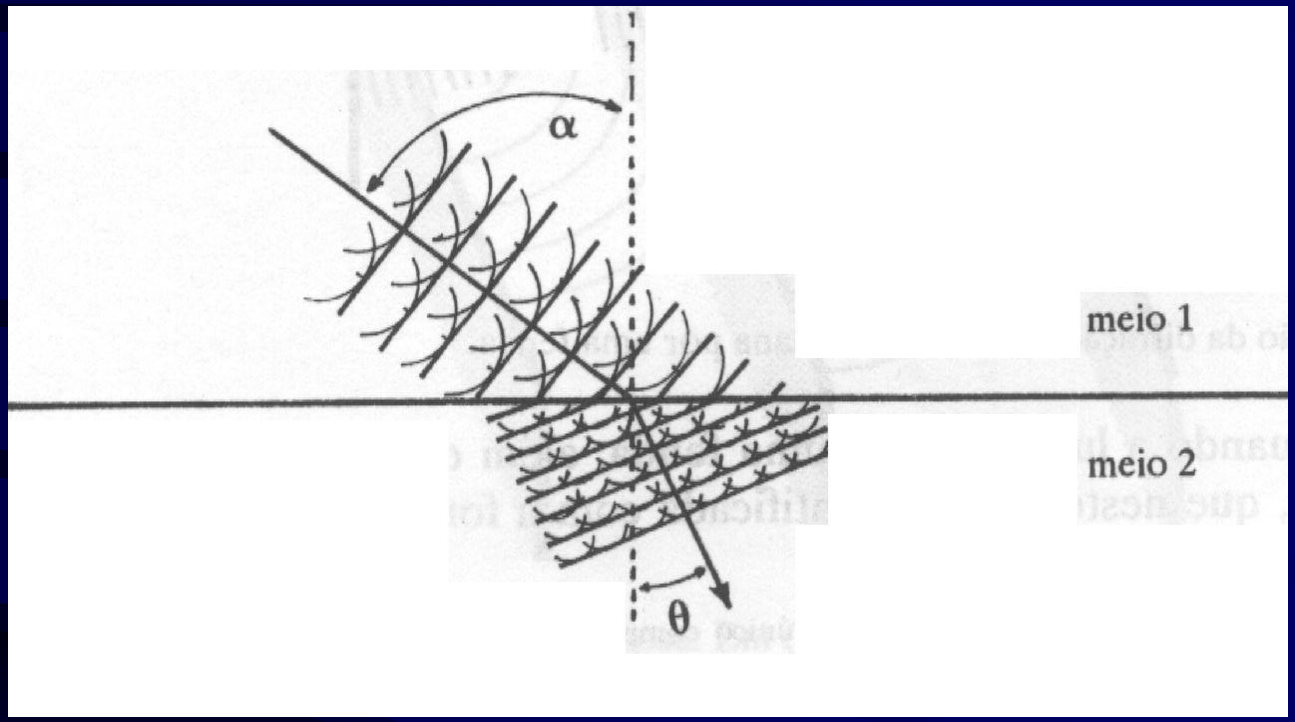
1ª) O raio incidente, o raio refletido e a normal são coplanares.

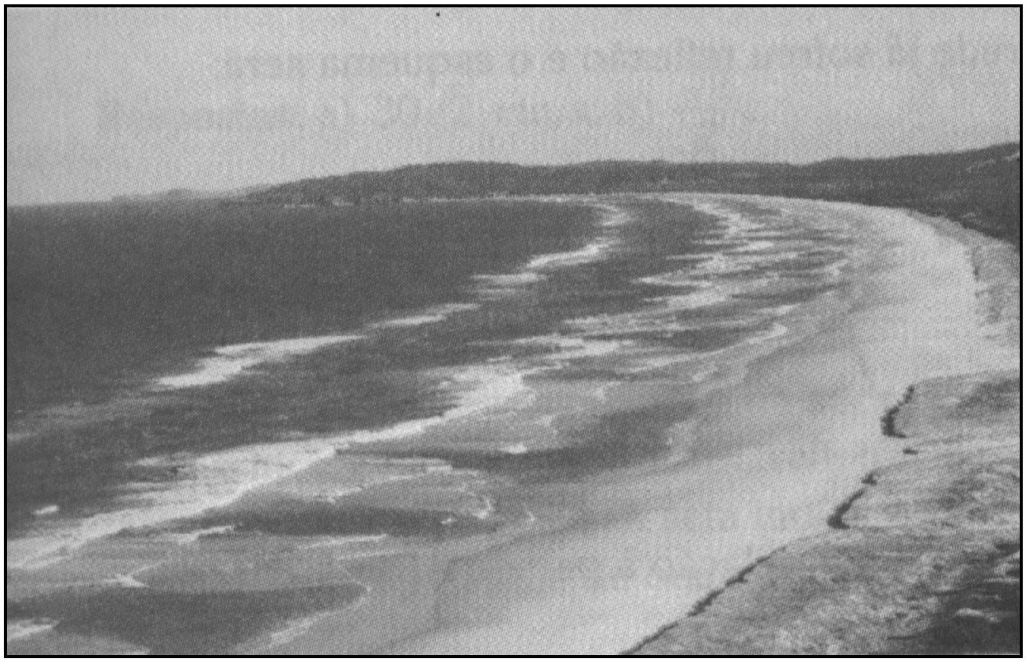
2ª) O ângulo de incidência é igual ao ângulo de reflexão.

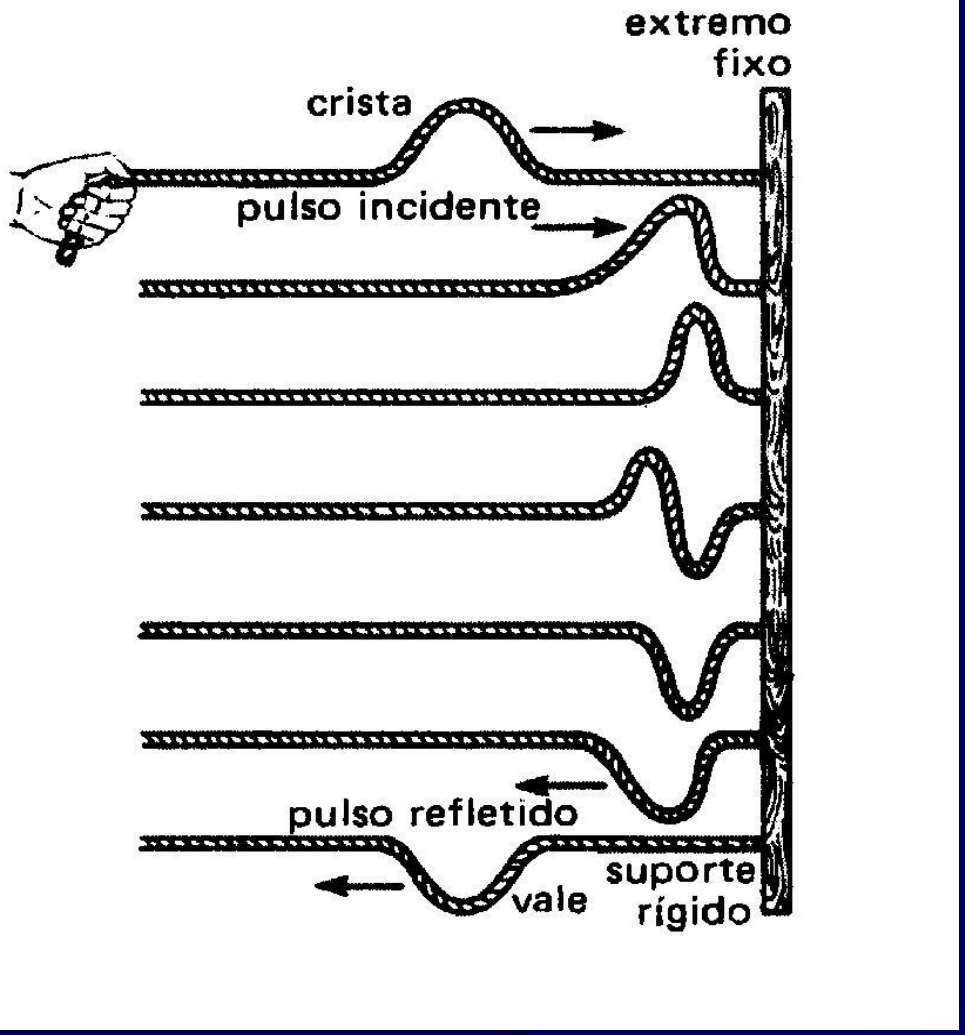
Propriedades

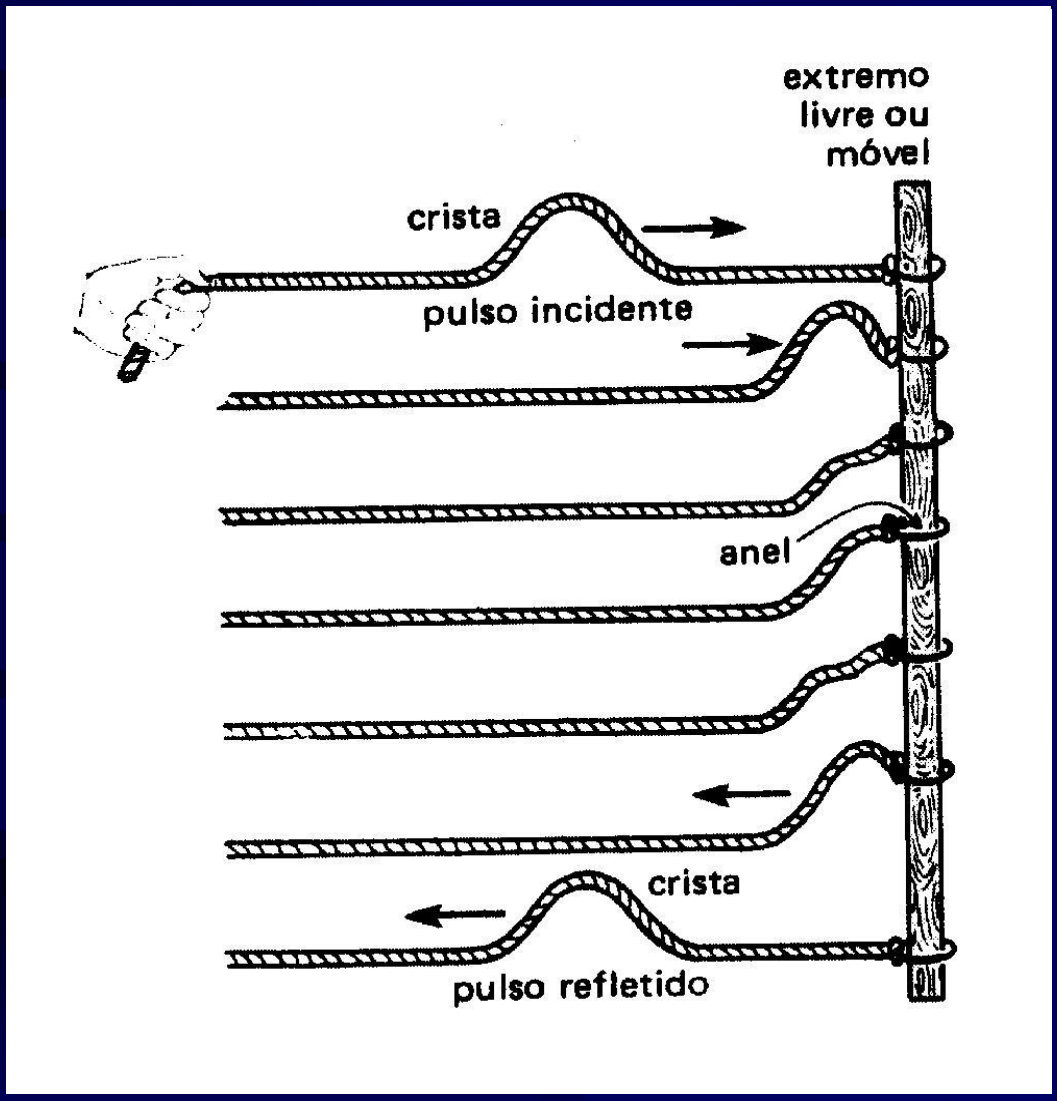
1ª) Na reflexão, a freqüência, a velocidade e o comprimento de onda não variam.

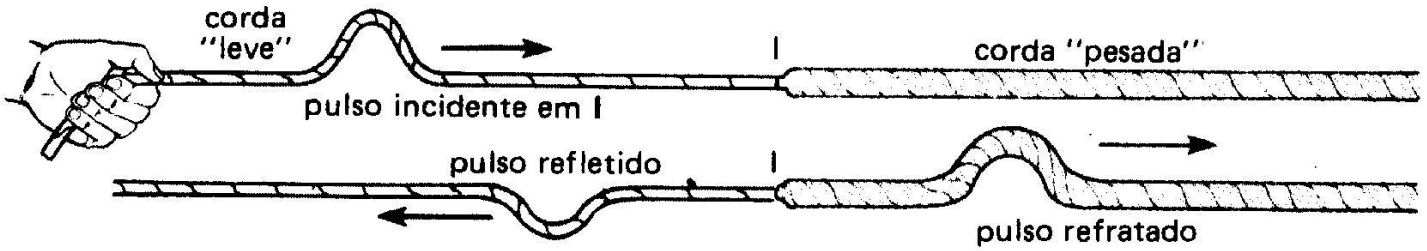
2ª) Na reflexão, a fase pode variar ou não.


α
meio 1
meio 2
θ

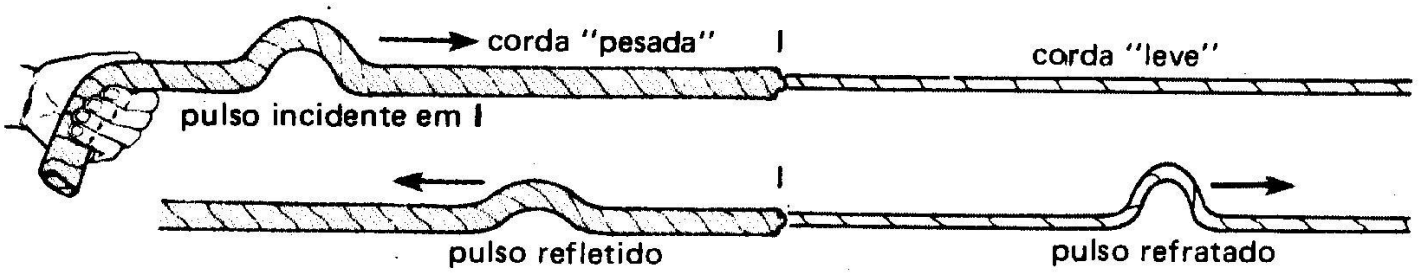


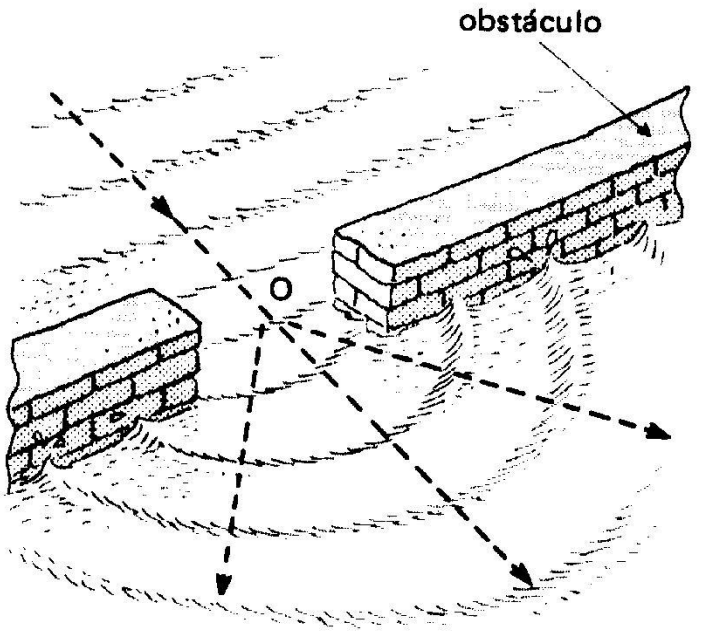

extremo
fixo
crista
pulso incidente
pulso refletido
vale
suporte
rígido

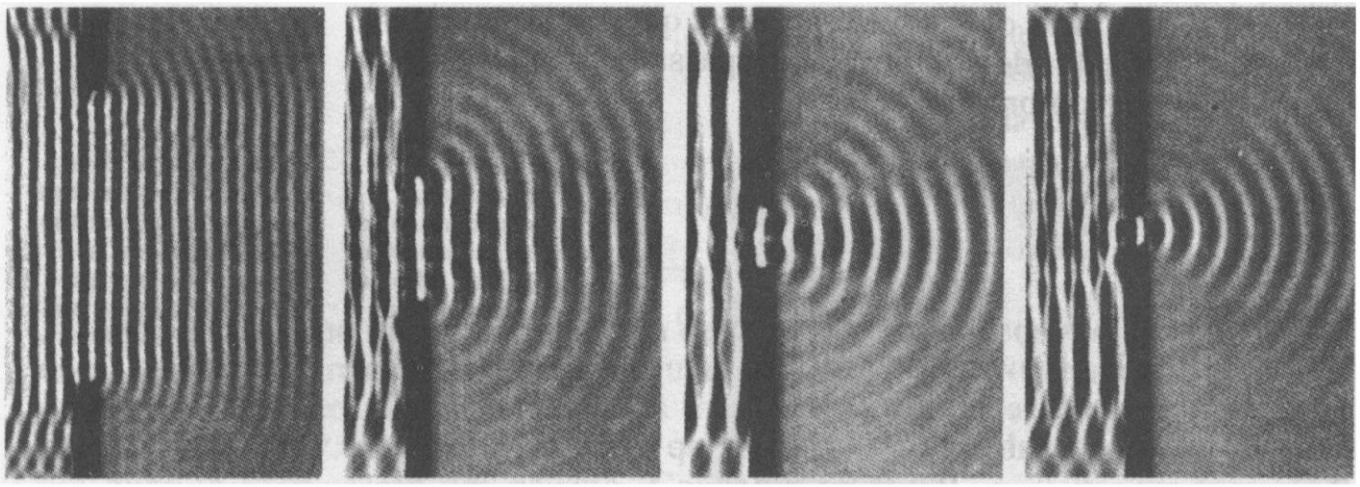

extremo
livre ou
móvel
crista
pulso incidente
anel
crista
pulso refletido



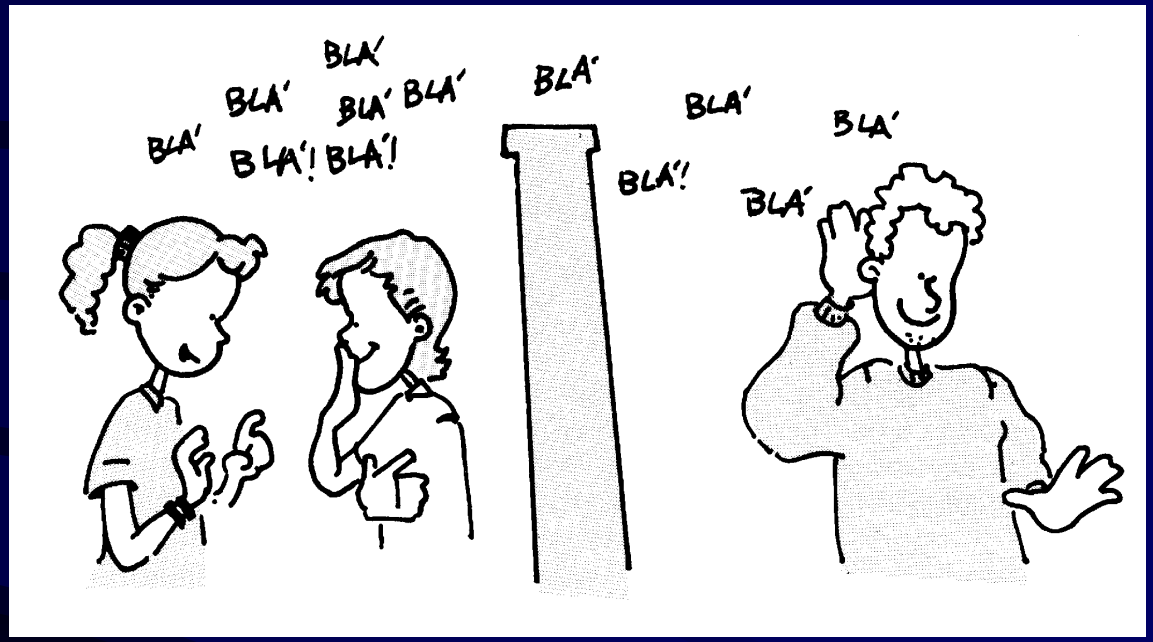
Refração e reflexão simultâneas.


corda "pesada"
corda "leve"
pulso incidente em I
I
pulso refletido
pulso refratado

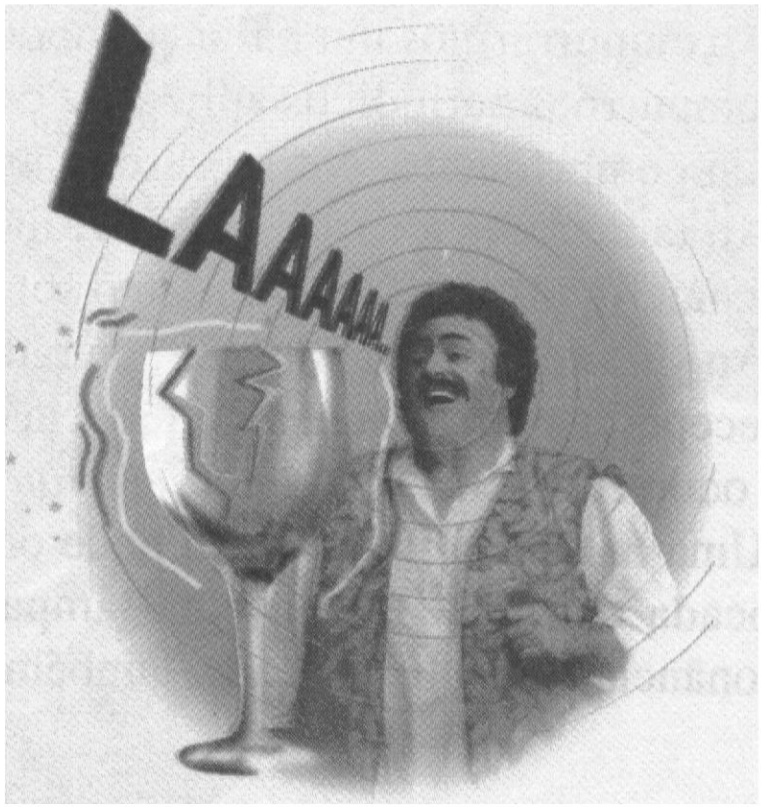

obstáculo
O

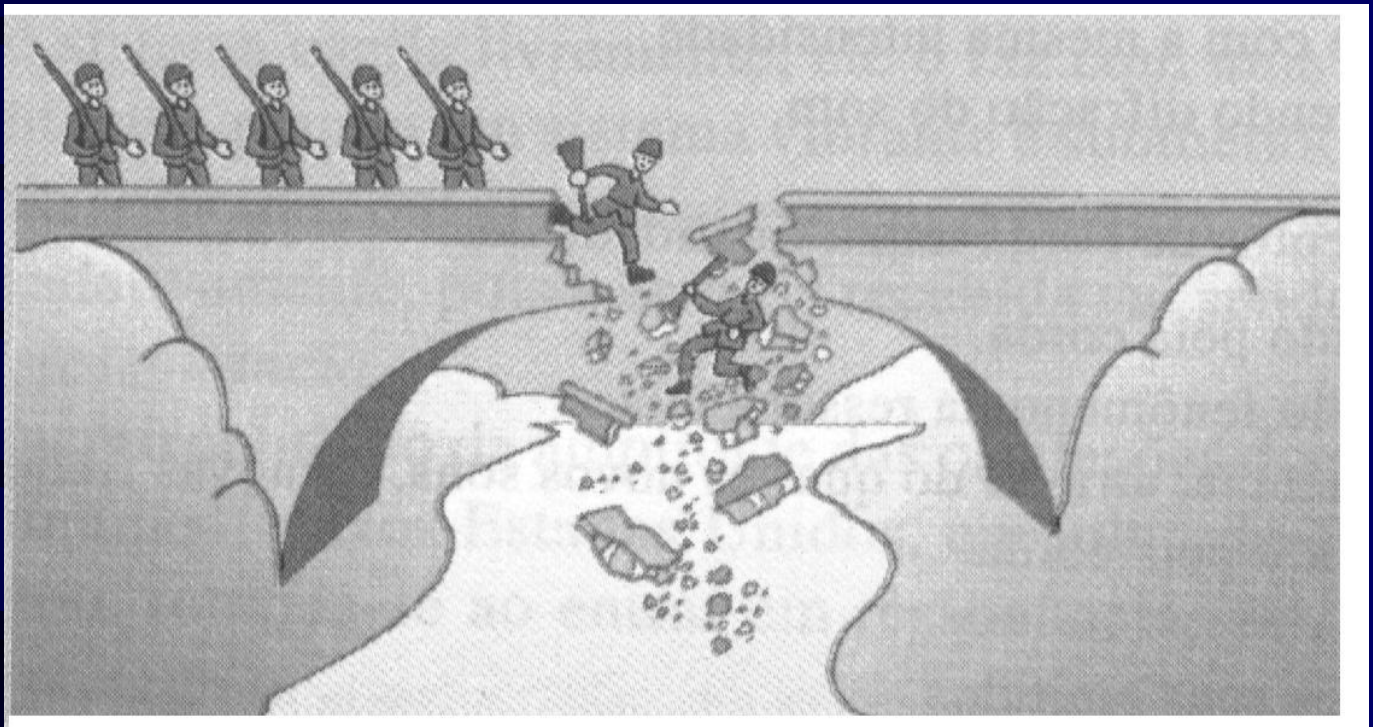


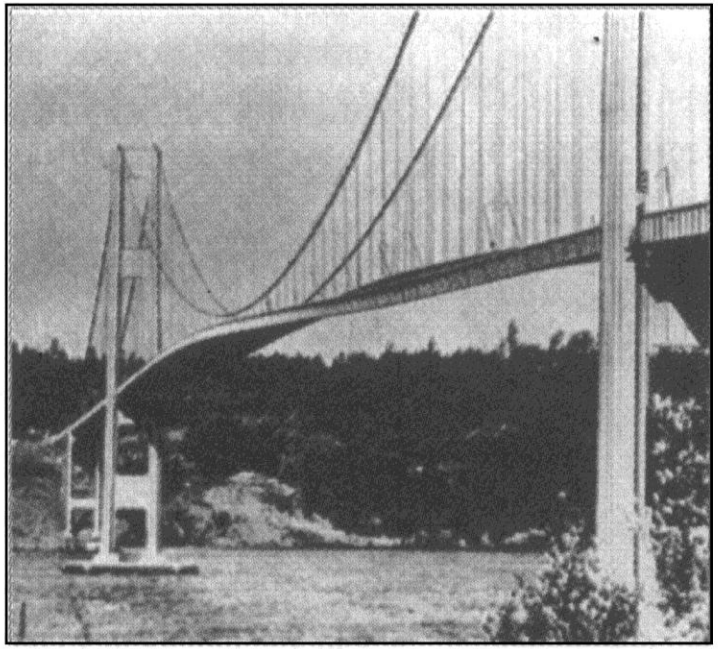
As ondas retilíneas que se propagam na superfície da água, provenientes da esquerda, encontram um obstáculo com uma abertura regulável. Quando a abertura é larga (figura da esquerda), as frentes de onda passam sem sofrer deformações e, em cada lado, forma-se uma zona de sombra bem-definida. Estreitando progressivamente a abertura, as frentes de onda se encurvam cada vez mais e invadem o que deveria ser a zona de sombra.

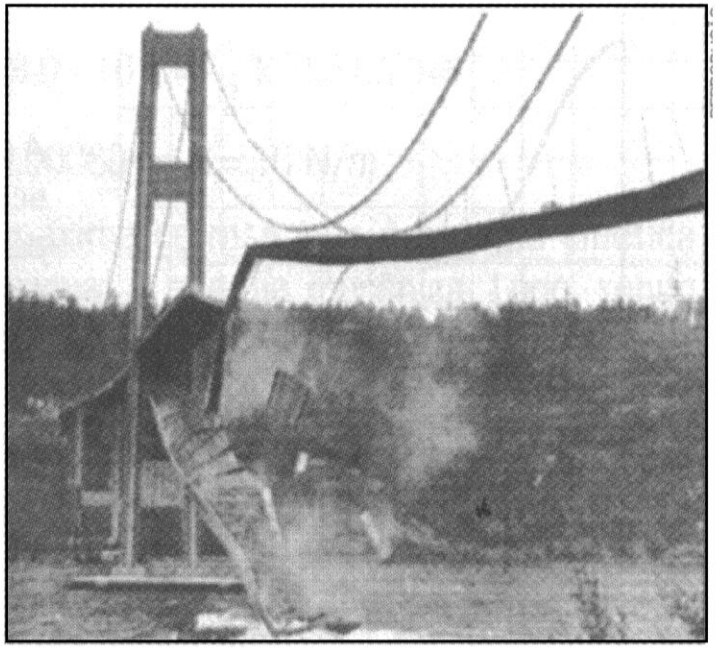

BLA'
BLA'
BLA'
BLA'
BLA'
BLA'
BLA'!
BLA'!
BLA'
BLA'
BLA'
BLA'!
BLA'

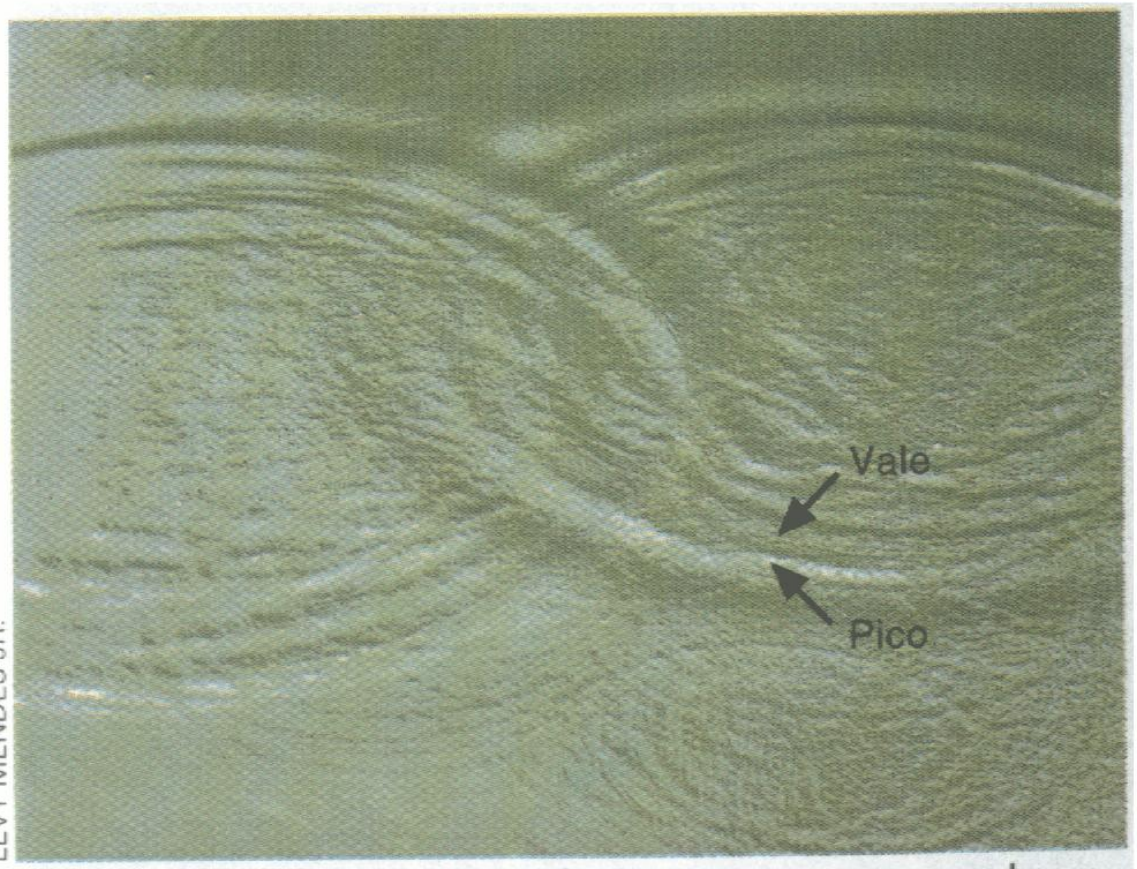

Bla bla bla bla!
Blabla bla blá ?...
Blá bla, bla bla!...
Bla,bla blá bla.
Bla? Bla bla bla ...
Bla blá bla bla!...


LAAAAAL



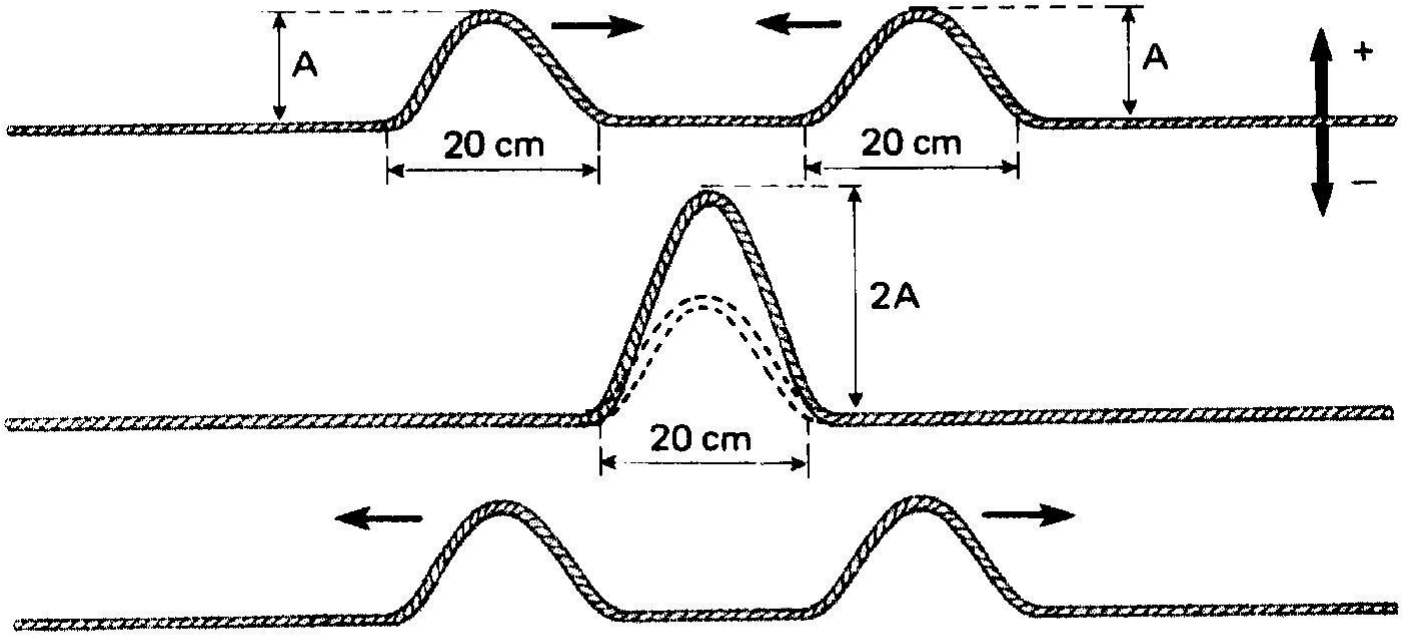




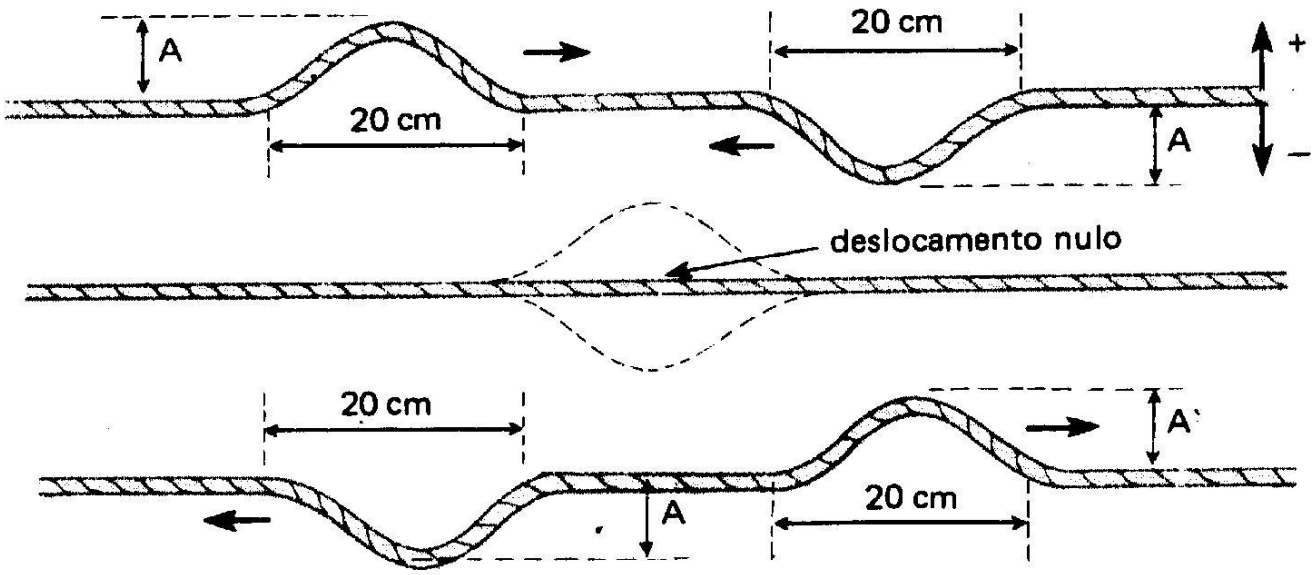


LEVY MENDES JR.

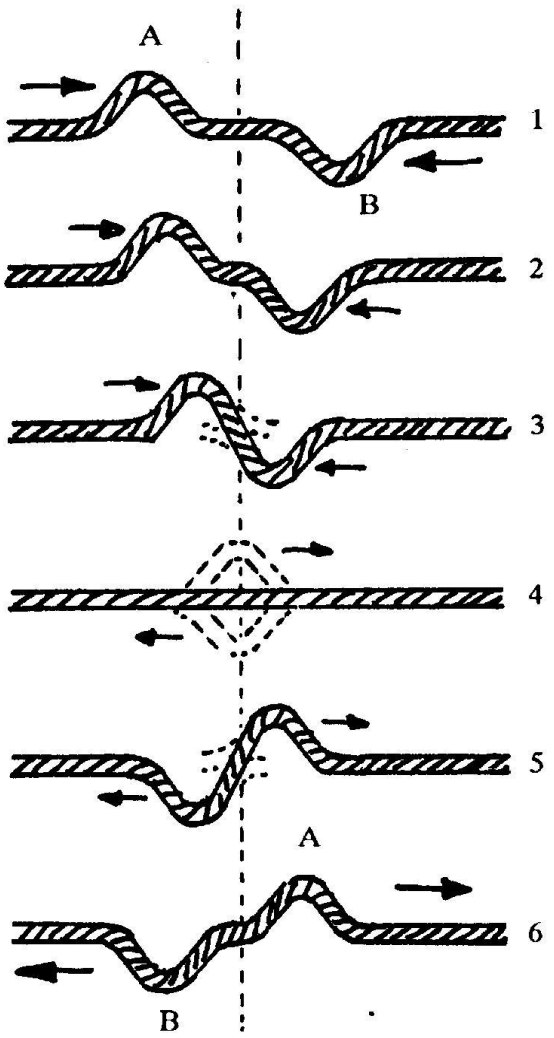
Fig. 1.8. Quando duas ondas se propagam, produzem interferência nos pontos em que se encontram. Aqui vemos o efeito em ondas na superfície da água.

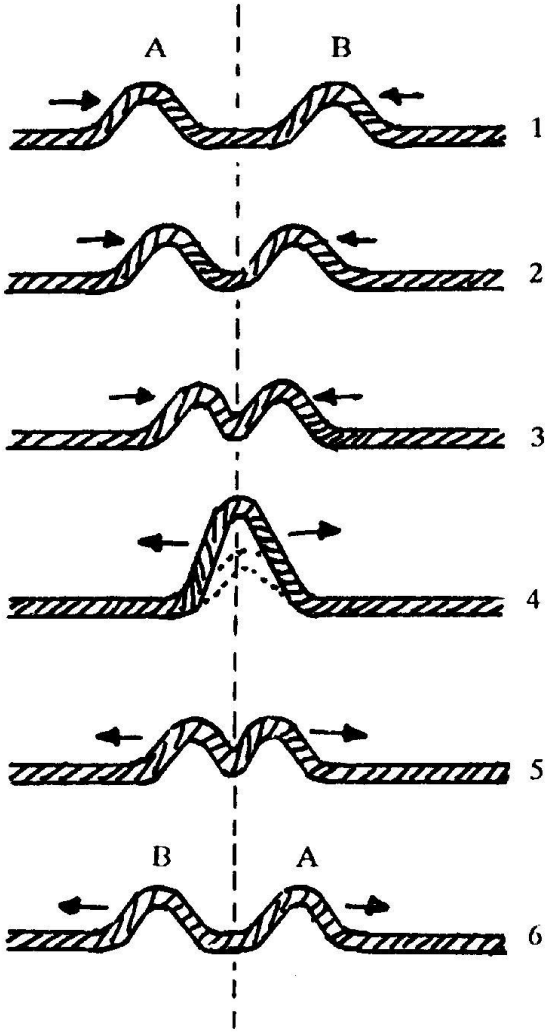


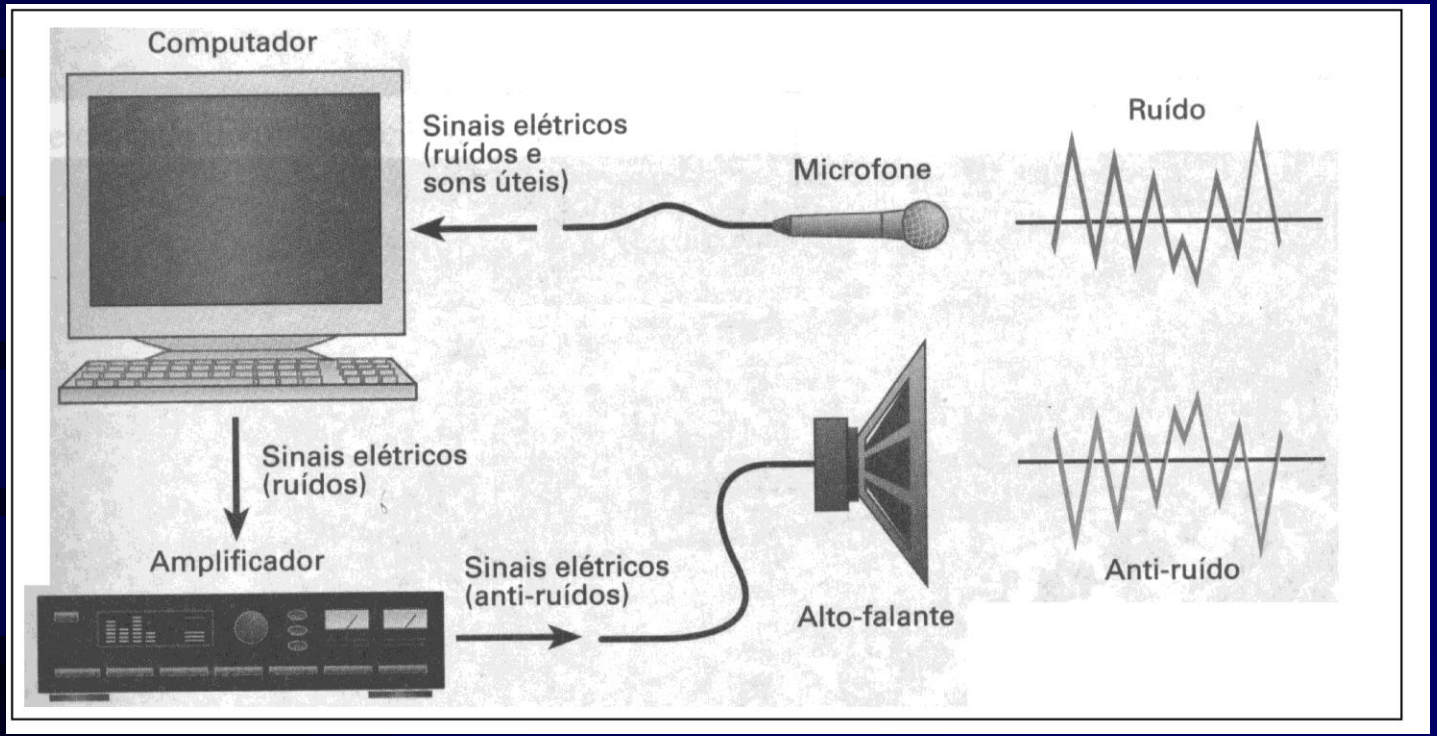
Interferência construtiva

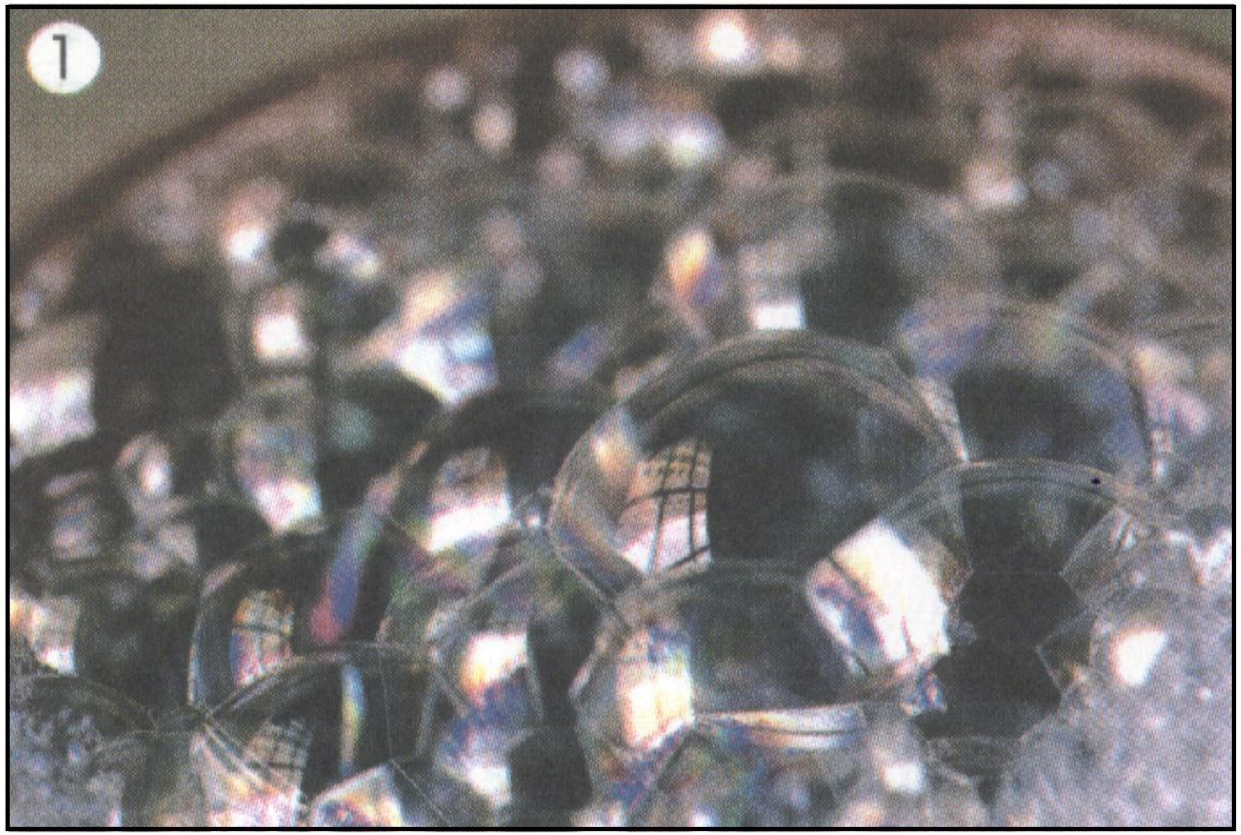


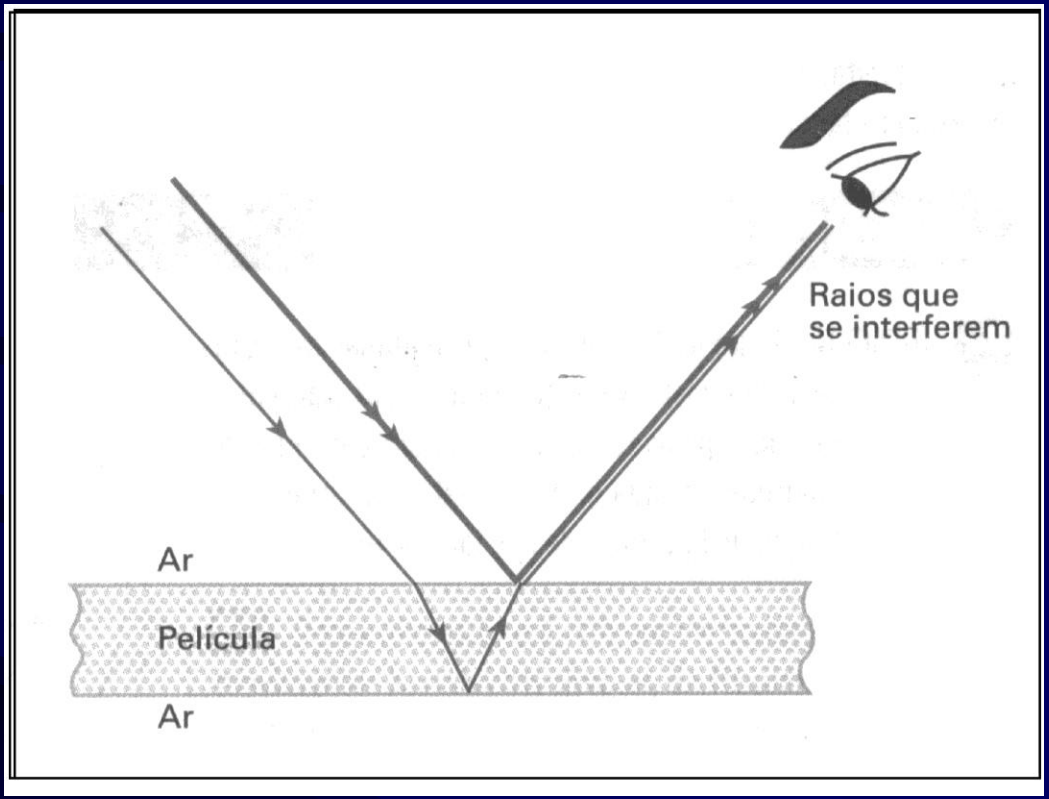
Interferência destrutiva

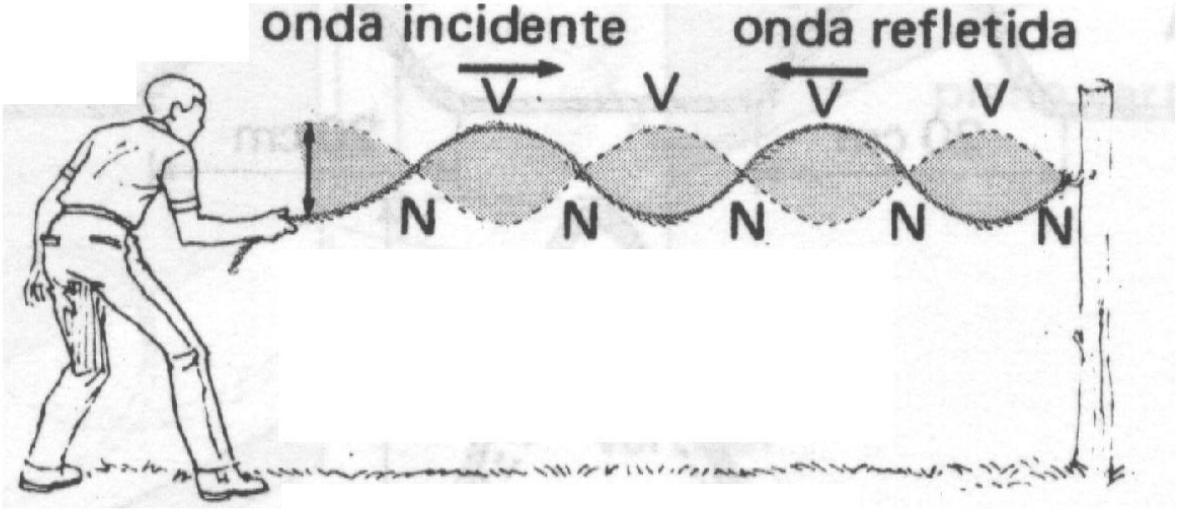

A
B
1
2
3
4
5
A
6
B

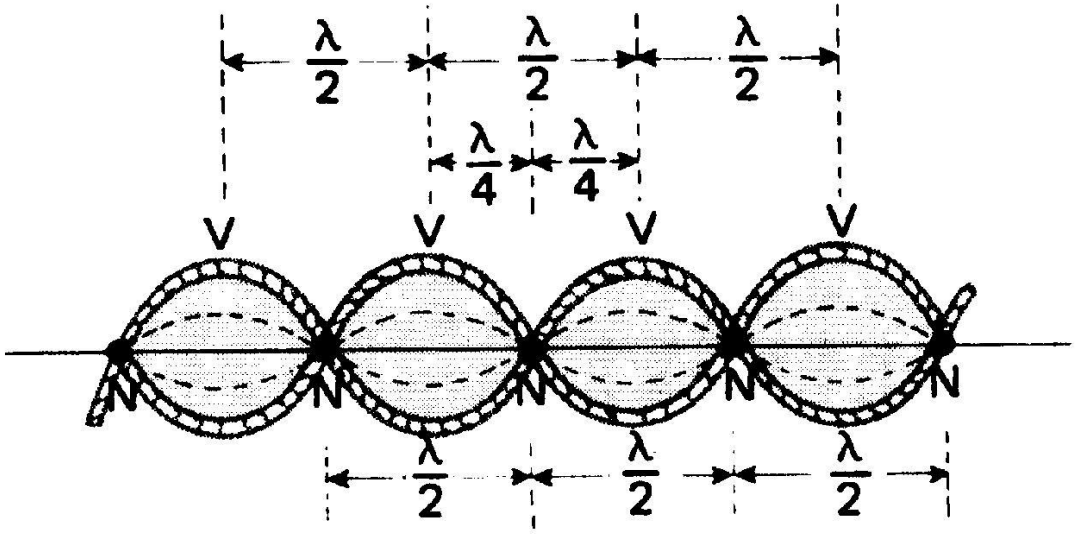

A
B
1
2
3
4
5
B
A
6

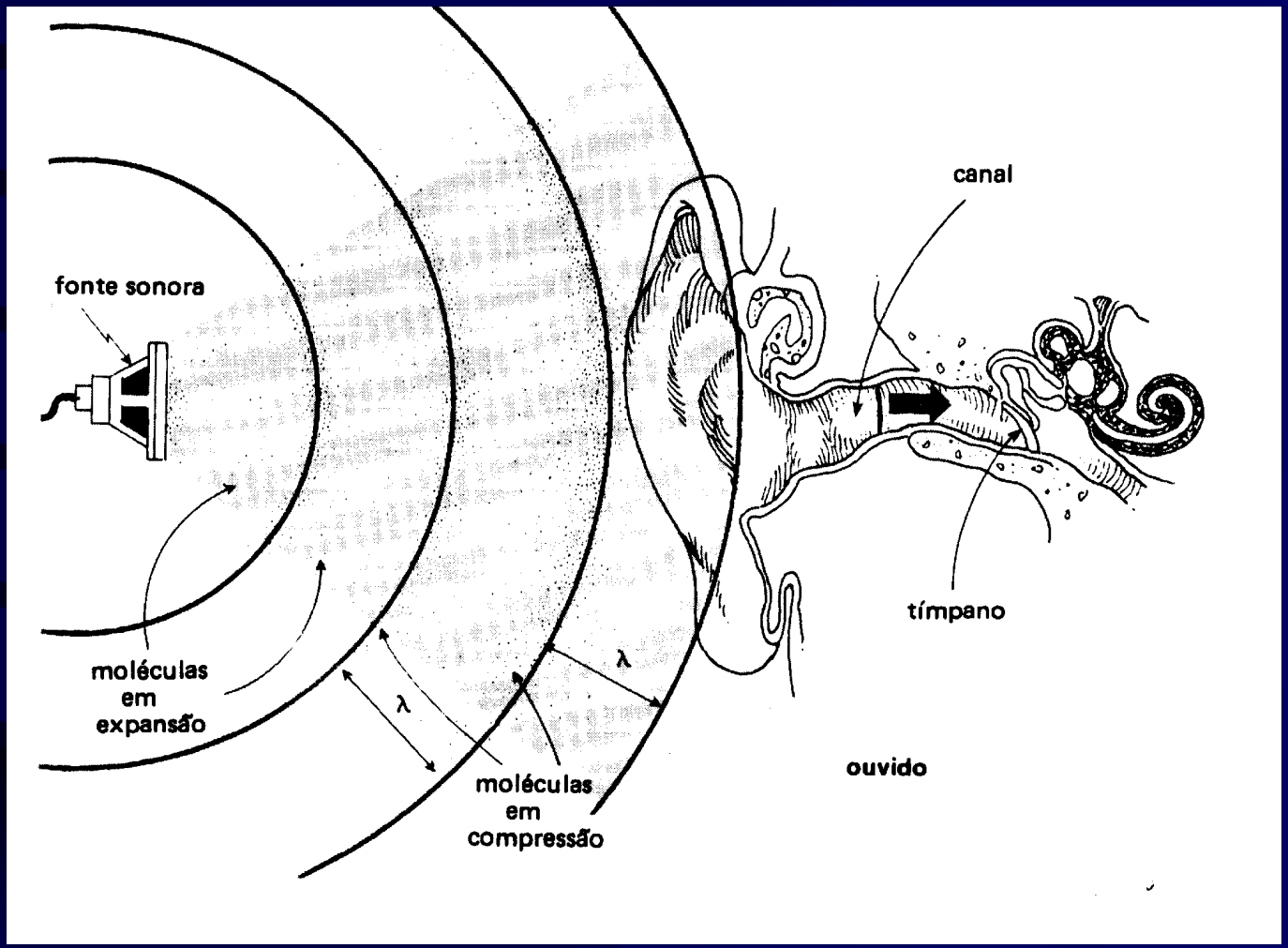

Computador
Sinais elétricos
(ruídos e
sons úteis)
Microfone
Ruído
Sinais elétricos
(ruídos)
Amplificador
Sinais elétricos
(anti-ruídos)
Alto-falante
Anti-ruído

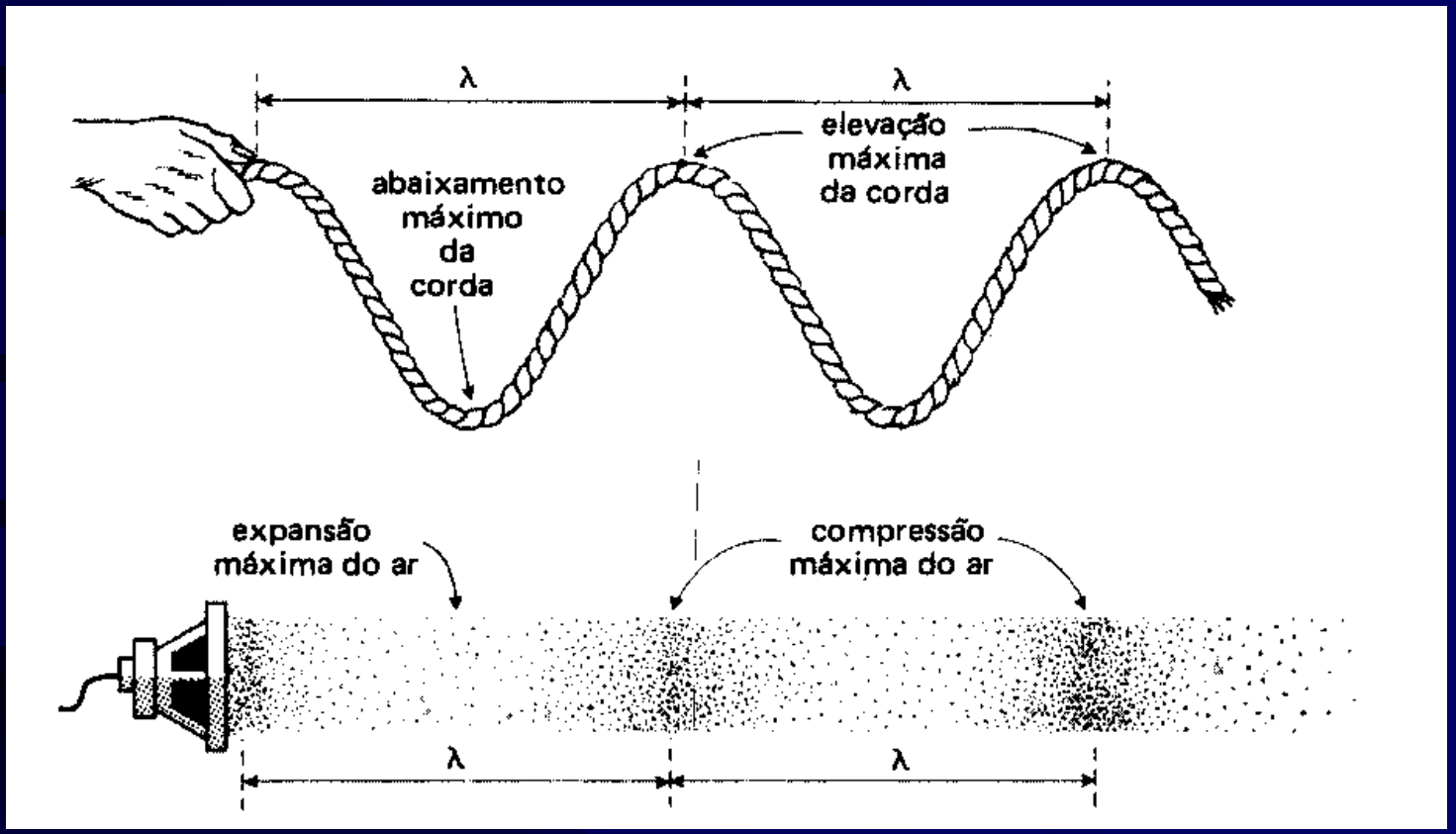

1

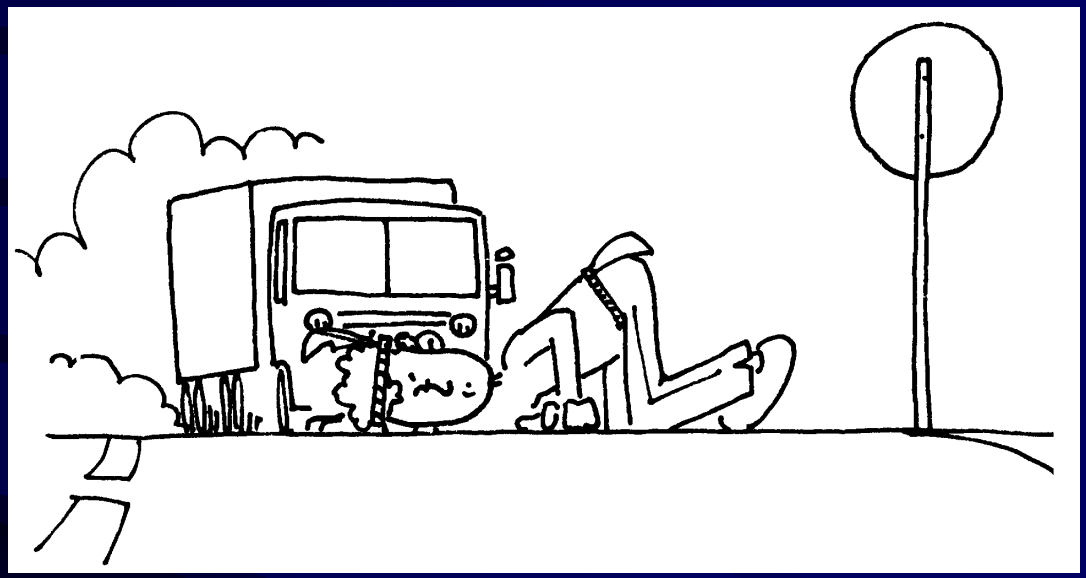

Raios que
se interferem
Ar
Película
Ar

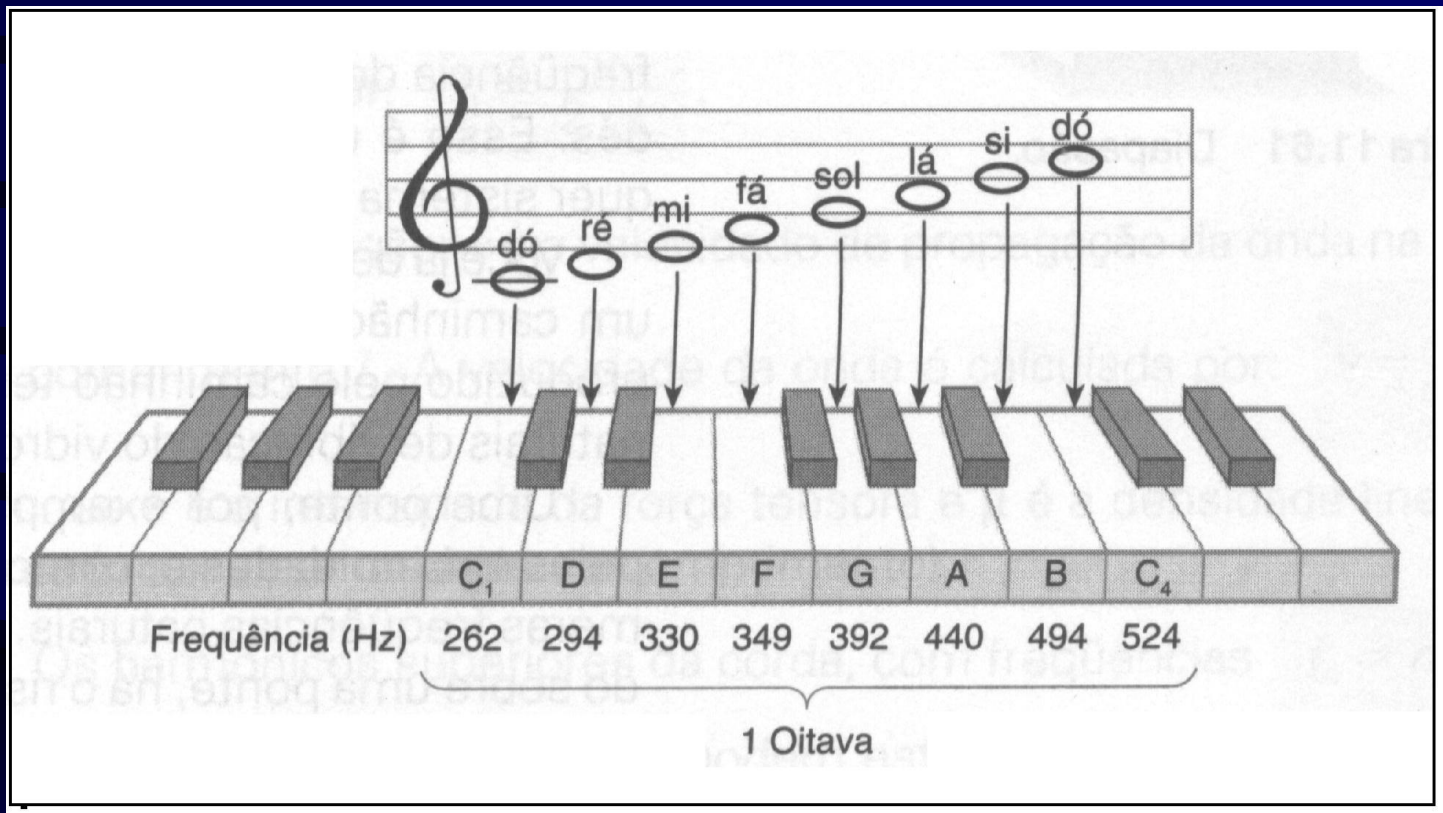

onda incidente
onda refletida
V
V
V
V
N
N
N
N
N

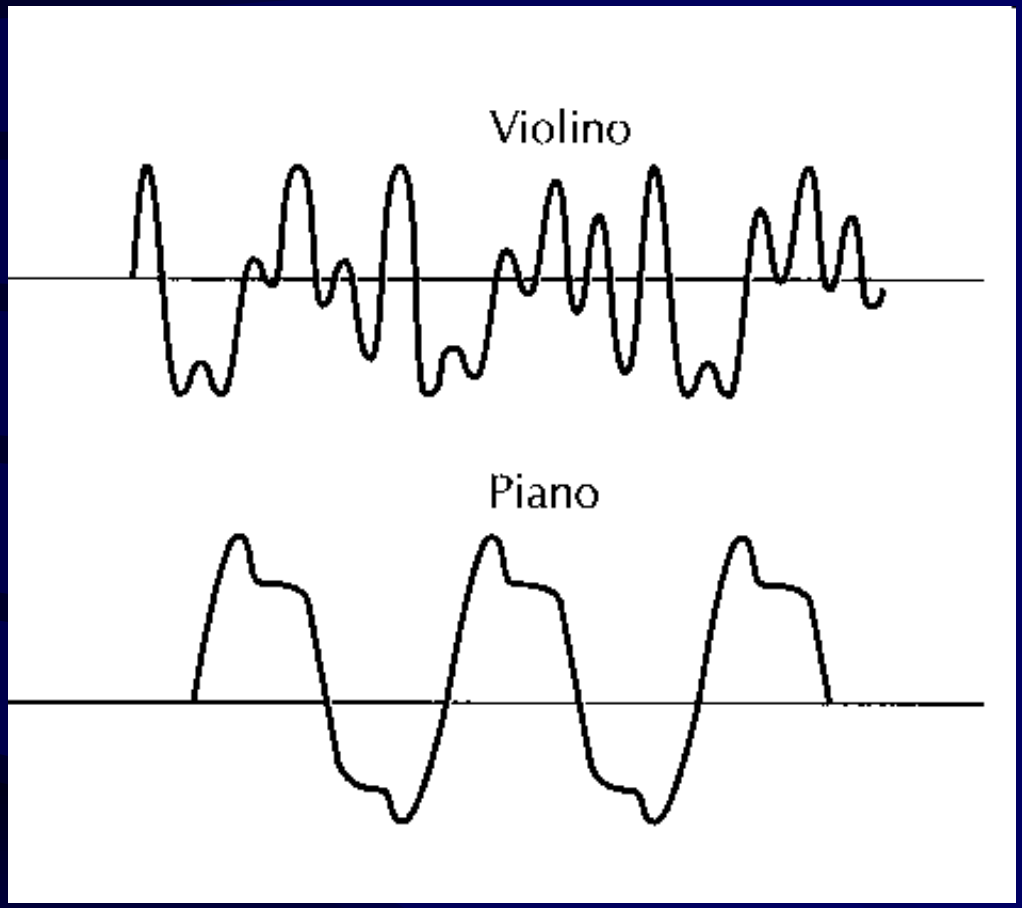

λ/2
λ/2
λ/2
λ/4
λ/4
V
V
V
V
N
N
N
N
N
λ/2
λ/2
λ/2

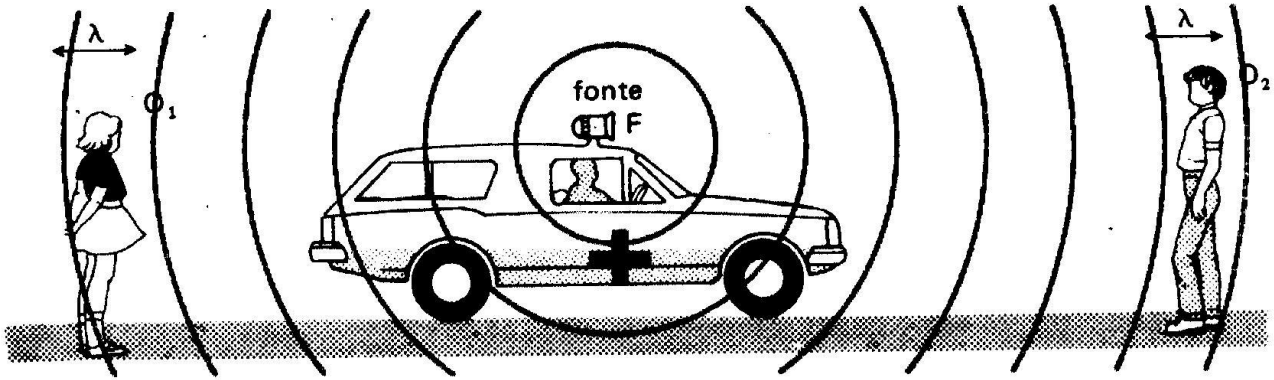

canal
fonte sonora
tímpano
moléculas em expansão
λ
λ
moléculas em compressão
ouvido


λ
λ
elevação
máxima
da corda
abaixamento
máximo
da
corda
expansão
máxima do ar
compressão
máxima do ar
λ
λ

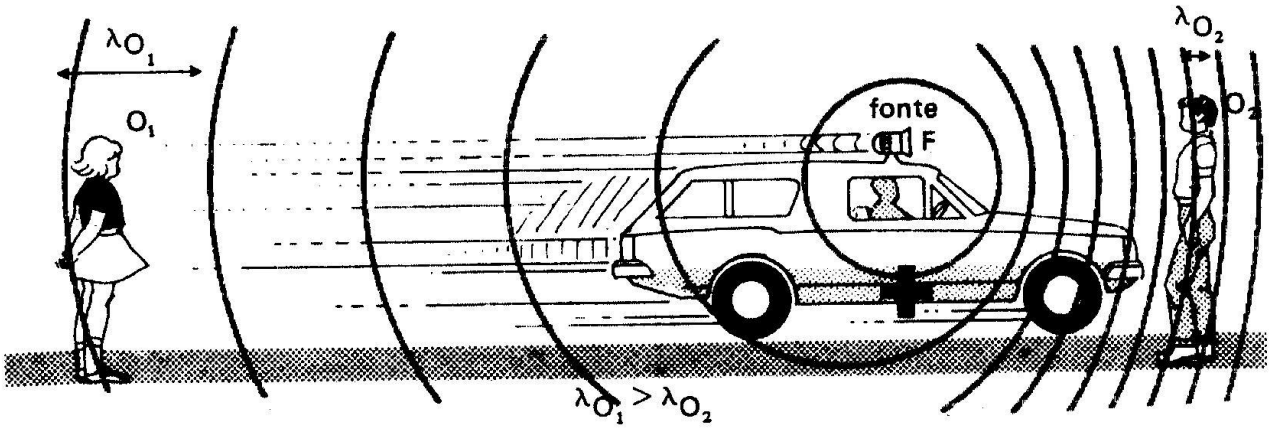



dó
ré
mi
fá
sol
lá
si
dó
C1
D
E
F
G
A
B
C4
Frequência (Hz) 262 294 330 349 392 440 494 524
1 Oitava

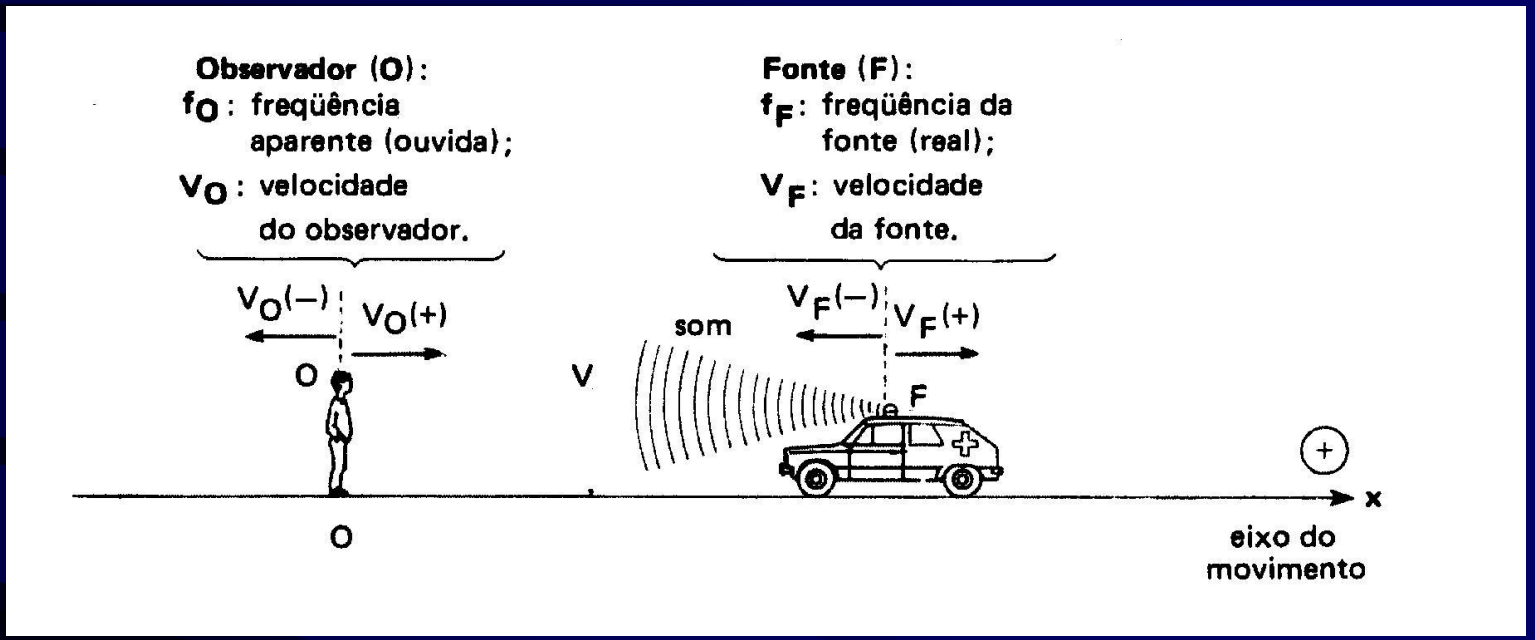

Violino
Piano

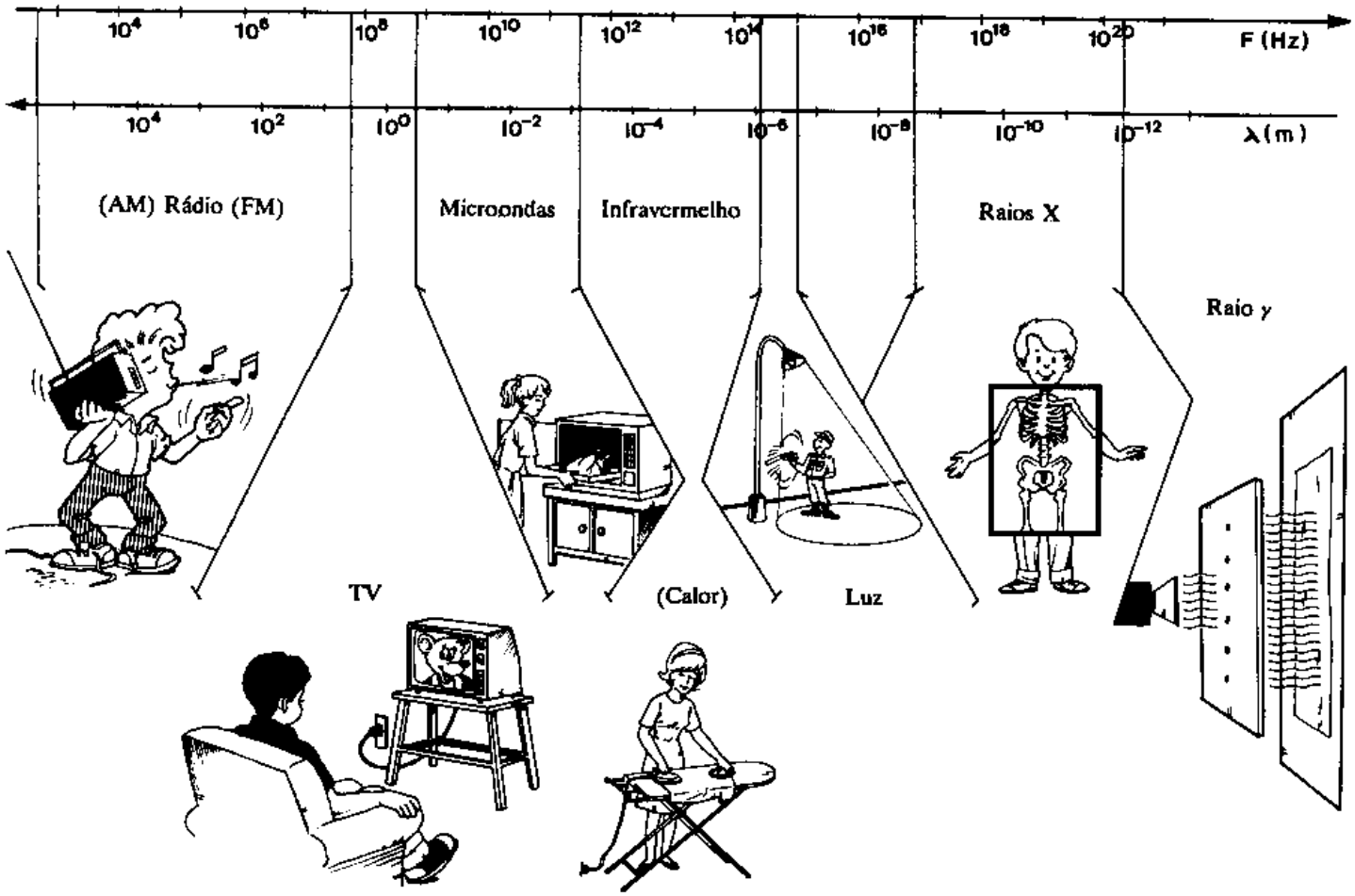


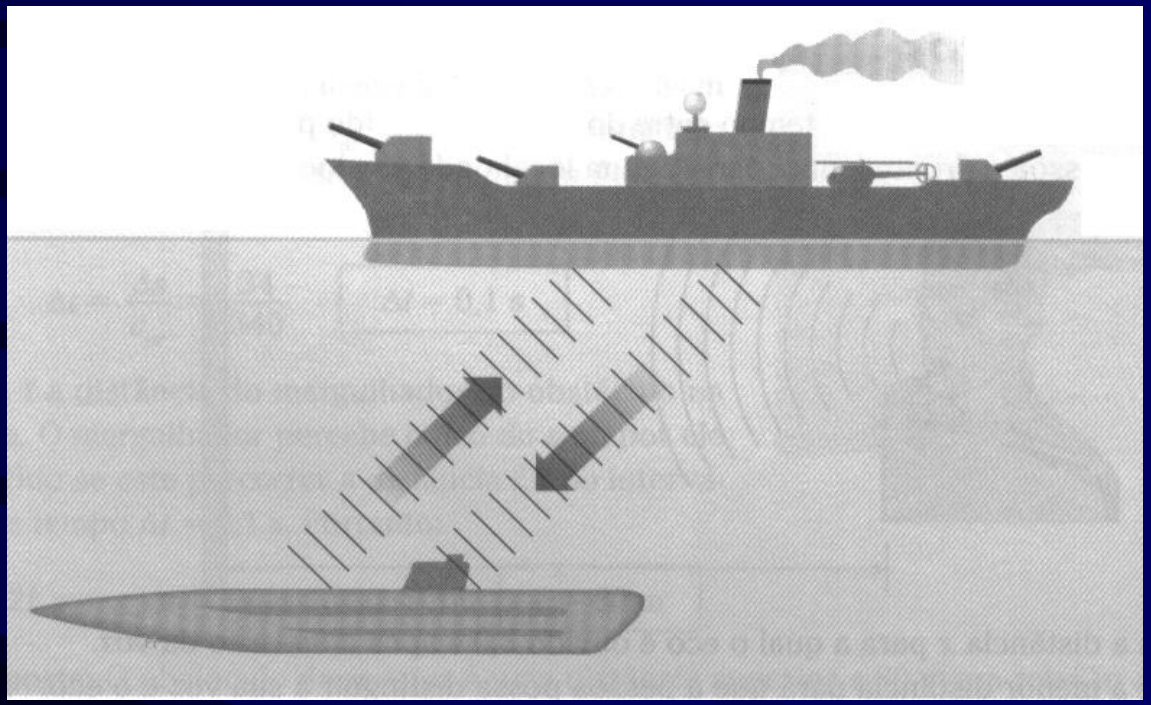
A fonte sonora **F** e os observadores O_1 e O_2 estão parados. Os sons recebidos por O_1 e O_2 têm a **mesma altura (mesma freqüência)**.

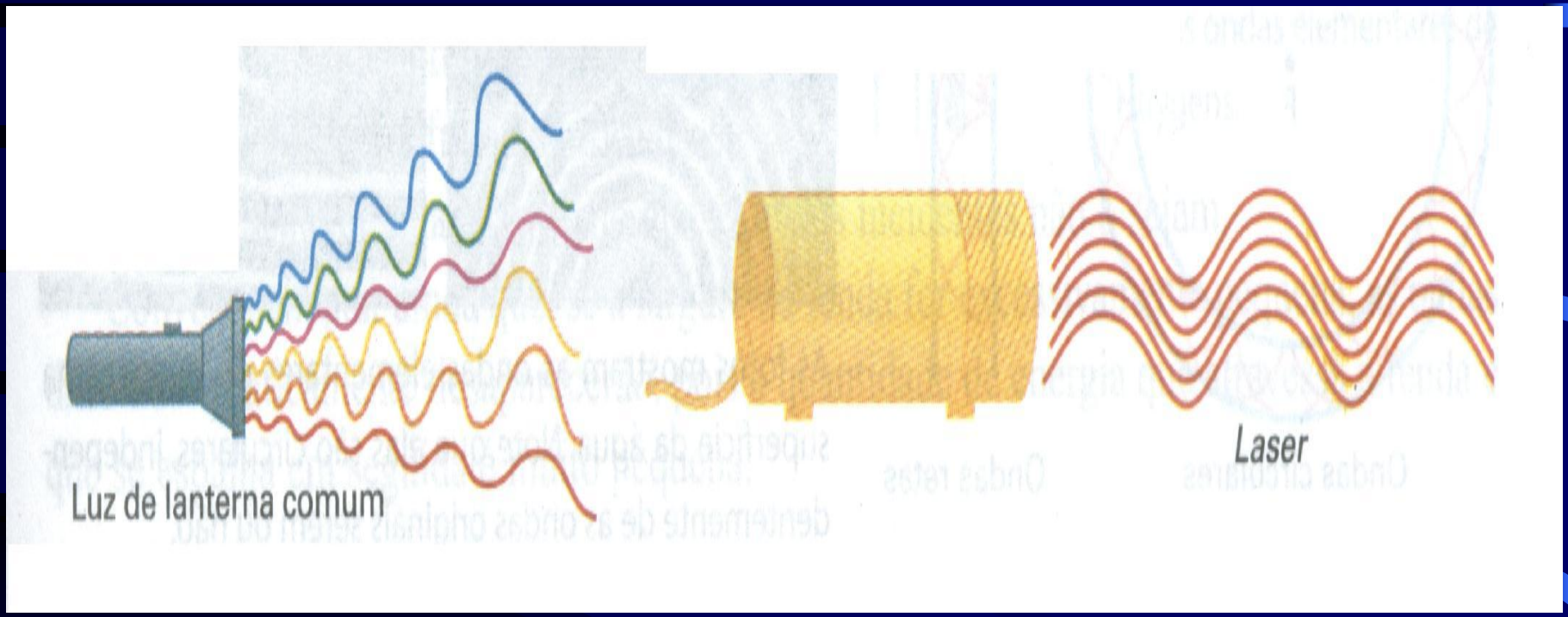


A fonte sonora **F** se aproxima de O_2 e se afasta de O_1. Para O_2 o som é **mais agudo (maior freqüência aparente)**; para O_1 o som é **mais grave (menor freqüência aparente)**.


Observador (O):
f_O: freqüência aparente (ouvida);
V_O: velocidade do observador.
Fonte (F):
f_F: freqüência da fonte (real);
V_F: velocidade da fonte.
$V_O(-)$
$V_O(+)$
O
$V_F(-)$
$V_F(+)$
som
V
F
+
x
O
eixo do movimento


10^4 10^6 10^8 10^{10} 10^{12} 10^{14} 10^{16} 10^{18} 10^{20} F (Hz)
10^4 10^2 10^0 10^{-2} 10^{-4} 10^{-6} 10^{-8} 10^{-10} 10^{-12} λ (m)
(AM) Rádio (FM)
Microondas
Infravermelho
Raios X
Raio γ
TV
(Calor)
Luz




Luz de lanterna comum
Laser

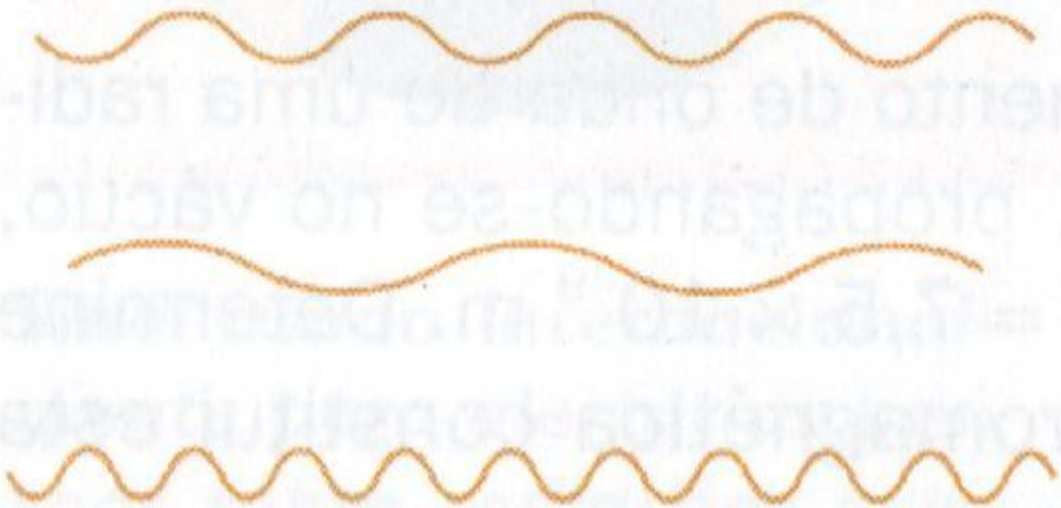


Fig. I: *A luz comum é constituída por uma mistura de radiações de diversas freqüências.*

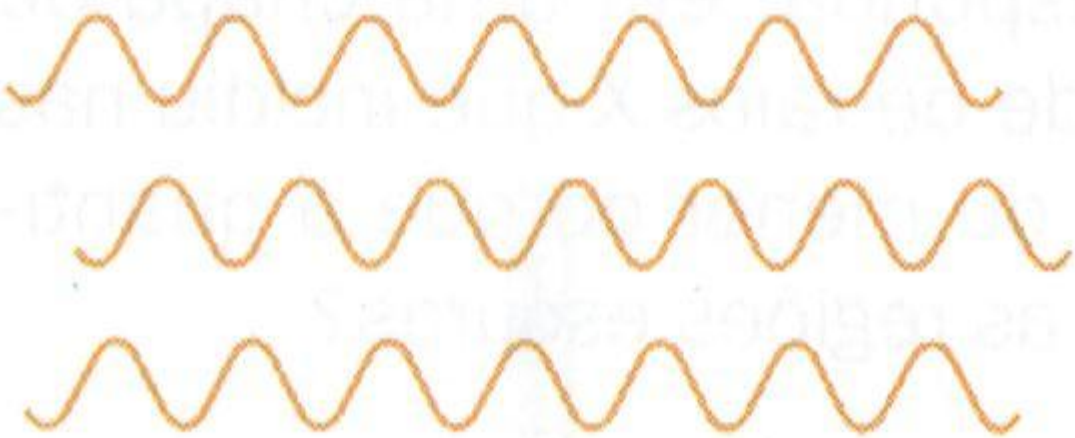
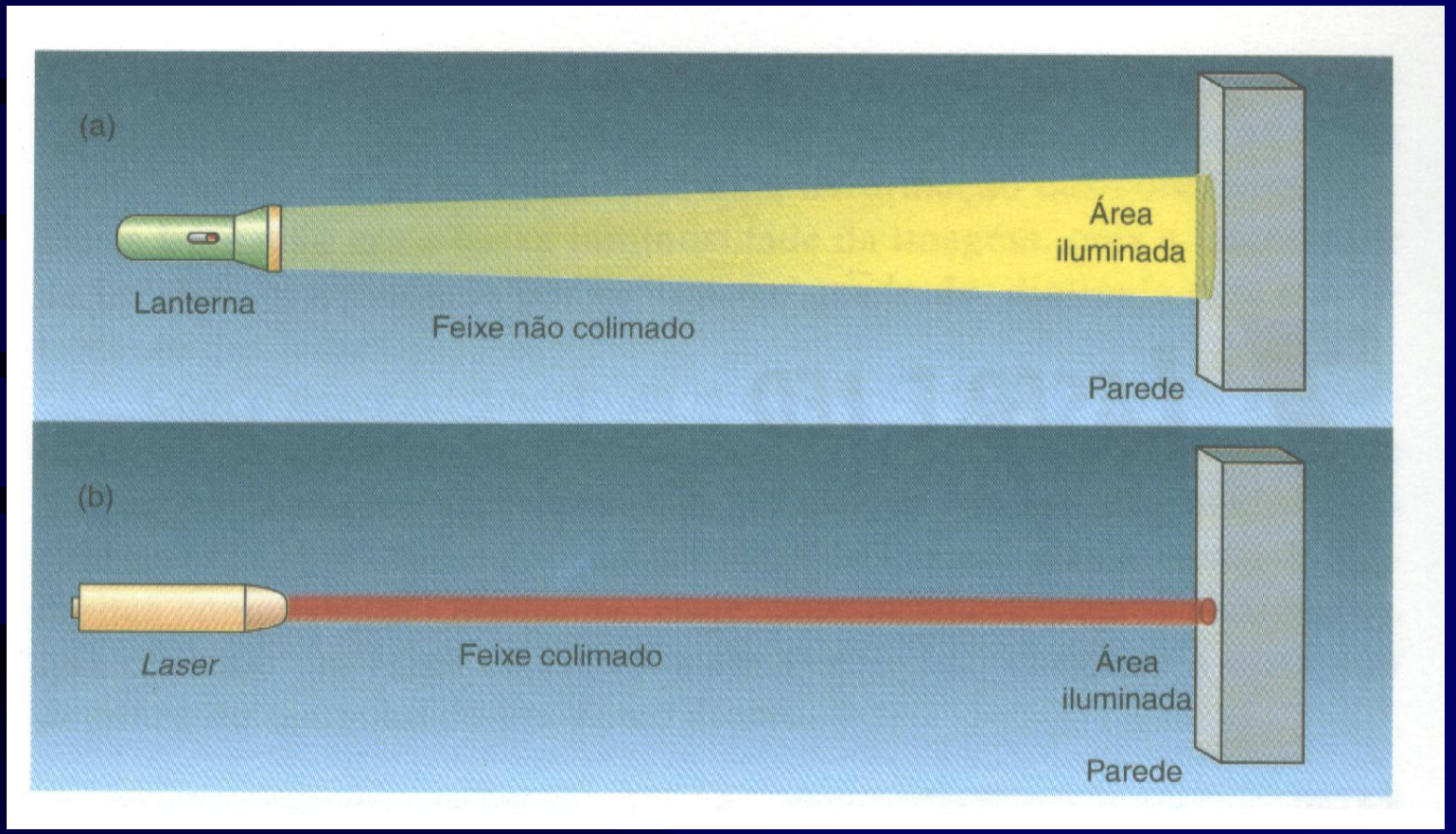
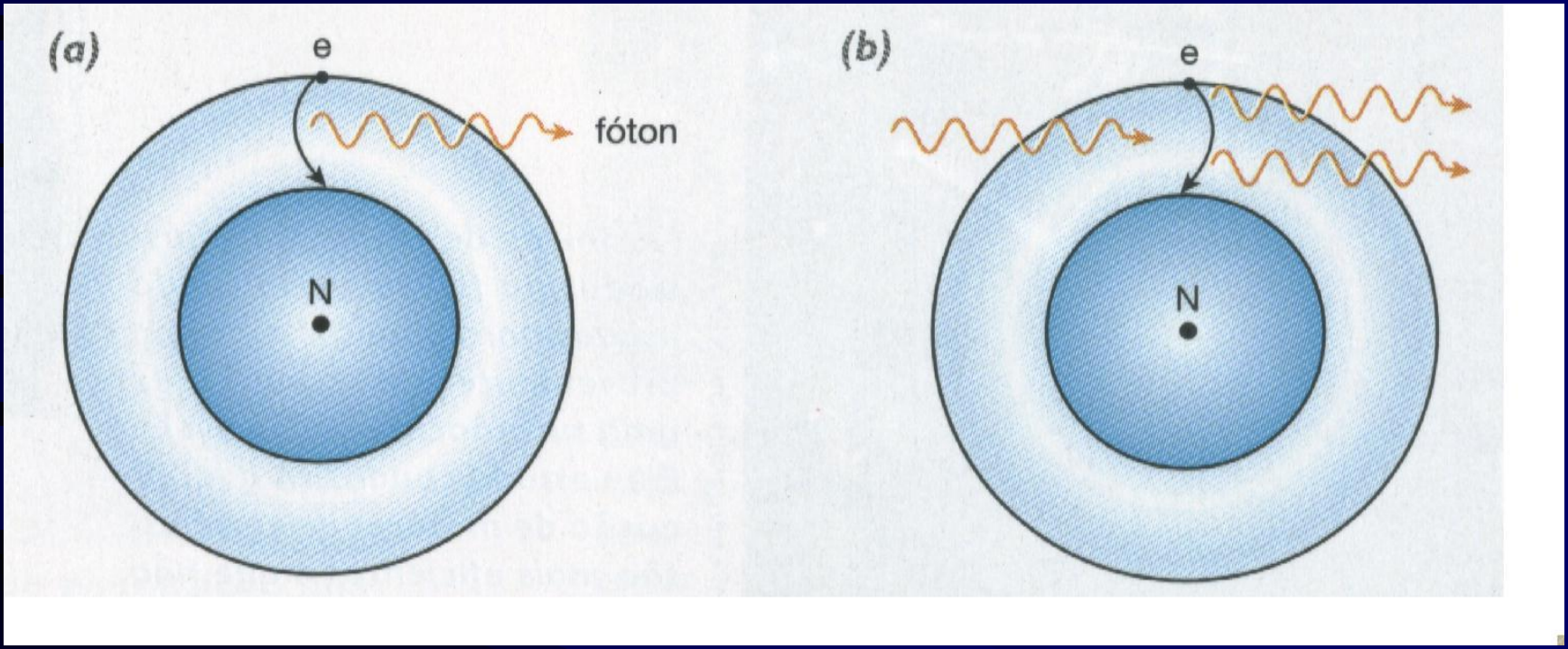


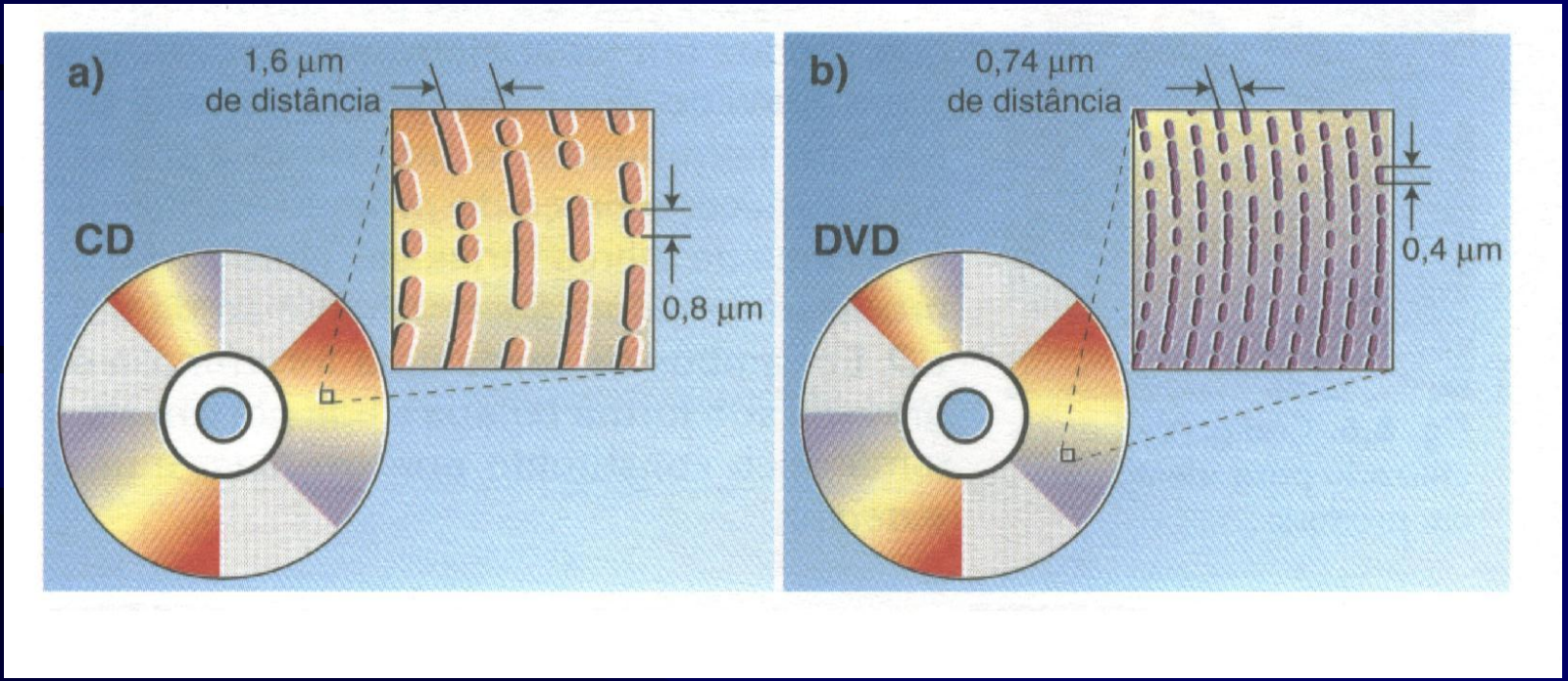
Fig. II: *A luz comum, mesmo quando é monocromática, apresenta-se incoerente.*

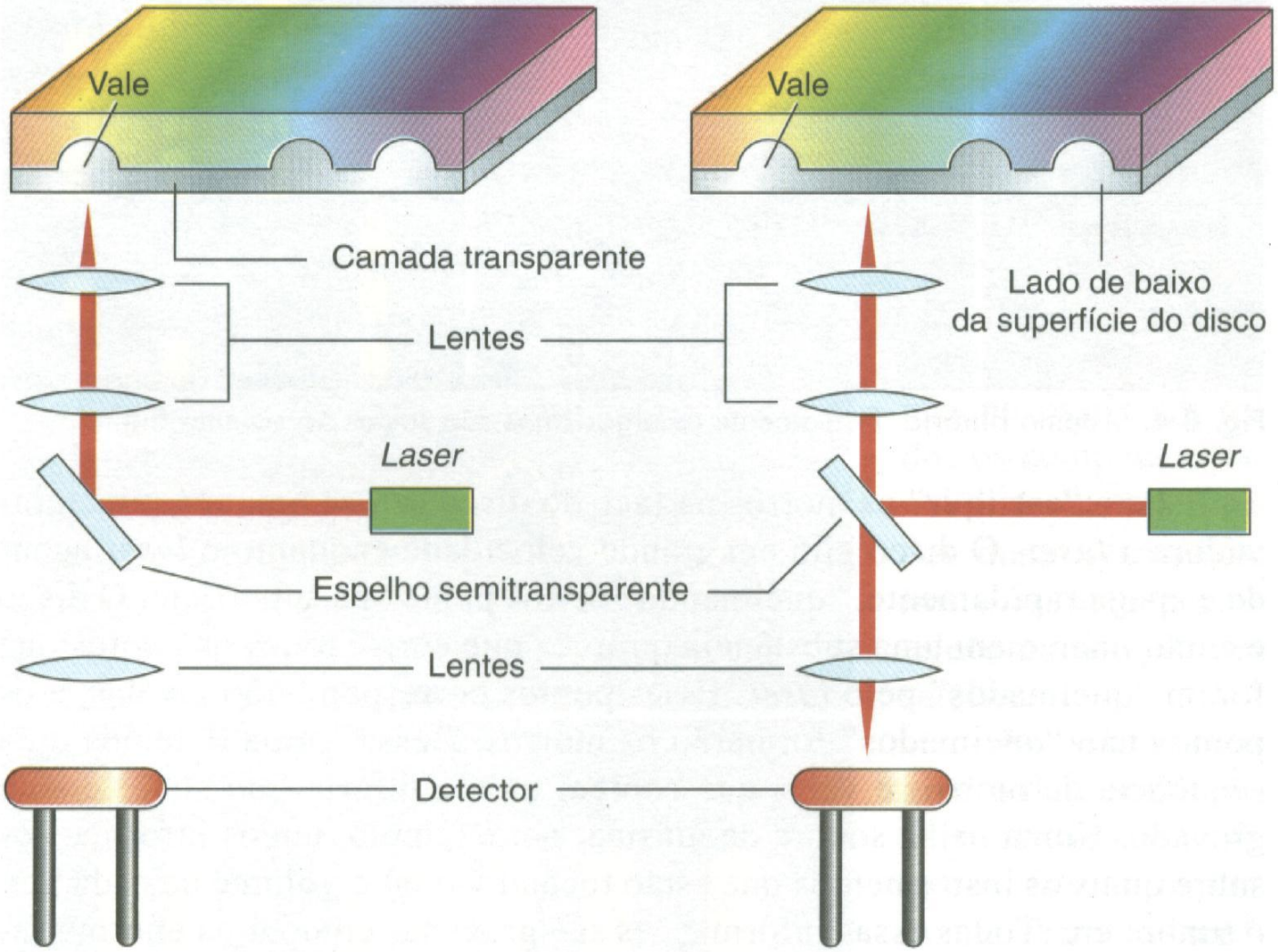
Fig. III: *A luz do laser é coerente.*


(a)
Área iluminada
Lanterna
Feixe não colimado
Parede
(b)
Laser
Feixe colimado
Área iluminada
Parede


(a)
e
fóton
N
(b)
e
N

Laser CD / DVD




Vale
Vale
Camada transparente
Lado de baixo
da superfície do disco
Lentes
Laser
Laser
Espelho semitransparente
Lentes
Detector