Relaxed Bandwidth Sharing with

Space Division Multiplexing

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www . inspiredresearch . com

Relaxed Bandwidth Sharing with

~~Space~~ Division Multiplexing

Distance + angle

Relaxed Bandwidth Sharing with

~~Space~~ Division Multiplexing

Distance + angle → ***directional antennae***

Relaxed Bandwidth Sharing with

~~Space~~ Division Multiplexing

Distance ***+ angle*** → *directional antennae*

→ *depth ~ holography*

(hence DDM, SDM)

background

wave effect recognized from astrophysics

informally

in 1995-1996 ~ predicted cosmological acceleration (Λ)

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in 1995-1996 ~ predicted cosmological acceleration (Λ)

in 1998-2000 ~ exact match + NASA spacecraft data
under Bruce Elmegreen, IBM Research
many partial ALL POSITIVE results
ground to 15+ Gy

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background

wave effect recognized from astrophysics

informally

in 1995-1996 ~ predicted cosmological acceleration (Λ)

in 1998-2000 ~ exact match + NASA spacecraft data
under Bruce Elmegreen, IBM Research
many partial ALL POSITIVE results
ground to 15+ Gy

in 2004 ~ isolated wave effect + a systematic fallacy in calibration of space telescopes

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opportunity

separation of signals by *source distance*

fundamental	not using content, e.g. GPS (*must* separate ***before*** demodulation *or* decoding)
universal	orthogonal to FDM, TDM, CDMA
could also cut	*noise & interference*

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opportunity

separation of signals by *source distance*

fundamental not using content, e.g. GPS
(*must* separate ***before*** demodulation *or* decoding)

universal orthogonal to FDM, TDM, CDMA

could also cut *noise & interference*

& would *multiply channel capacity*

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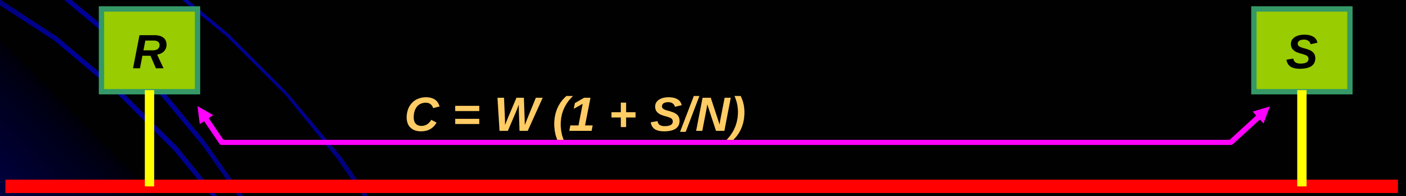
beyond Shannon's limit

- *Shannon theory ~ time × bandwidth*
  - fundamental dimensions =
    { time, frequency, direction, polarization }
  - *each dimension* ***multiplies*** *capacity*



R

S

$C = W (1 + S/N)$

channel capacity C (b/s)

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distance = new dimension

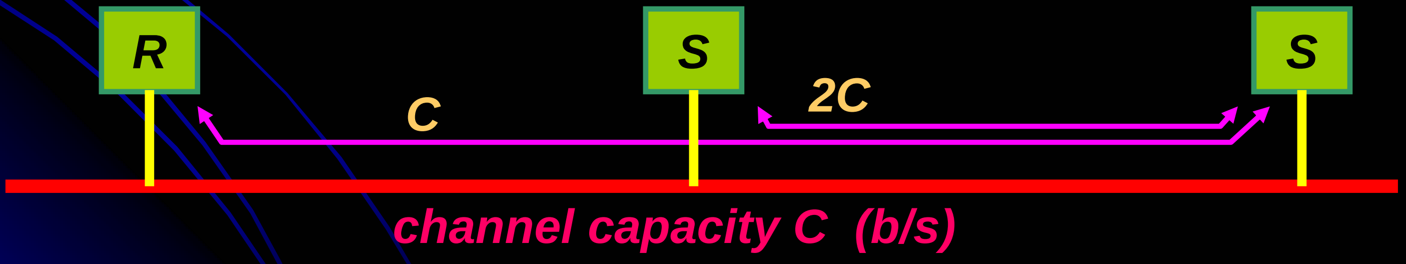
reuse full capacity for each source

avoid partitioning by time, frequency, code

or add more channels!

source in the middle attack!

how many?



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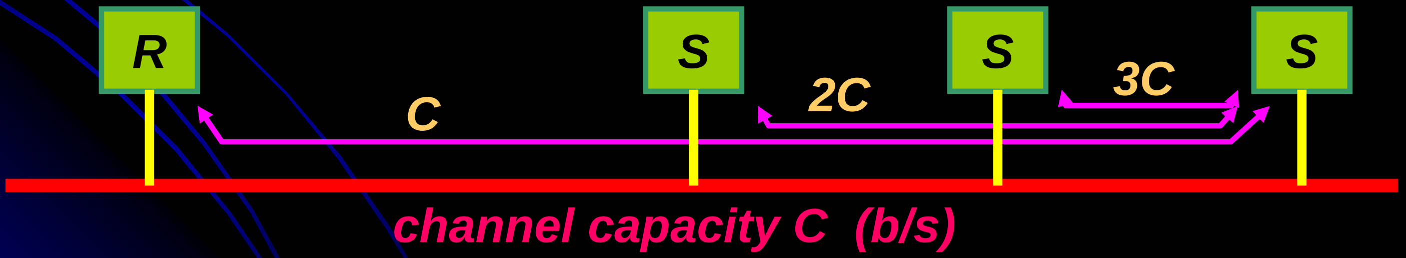
distance is a continuum

reuse full capacity for each source

avoid partitioning by time, frequency, code

or just *keep adding* more channels!

down to λ_{max} ~ Rayleigh limit



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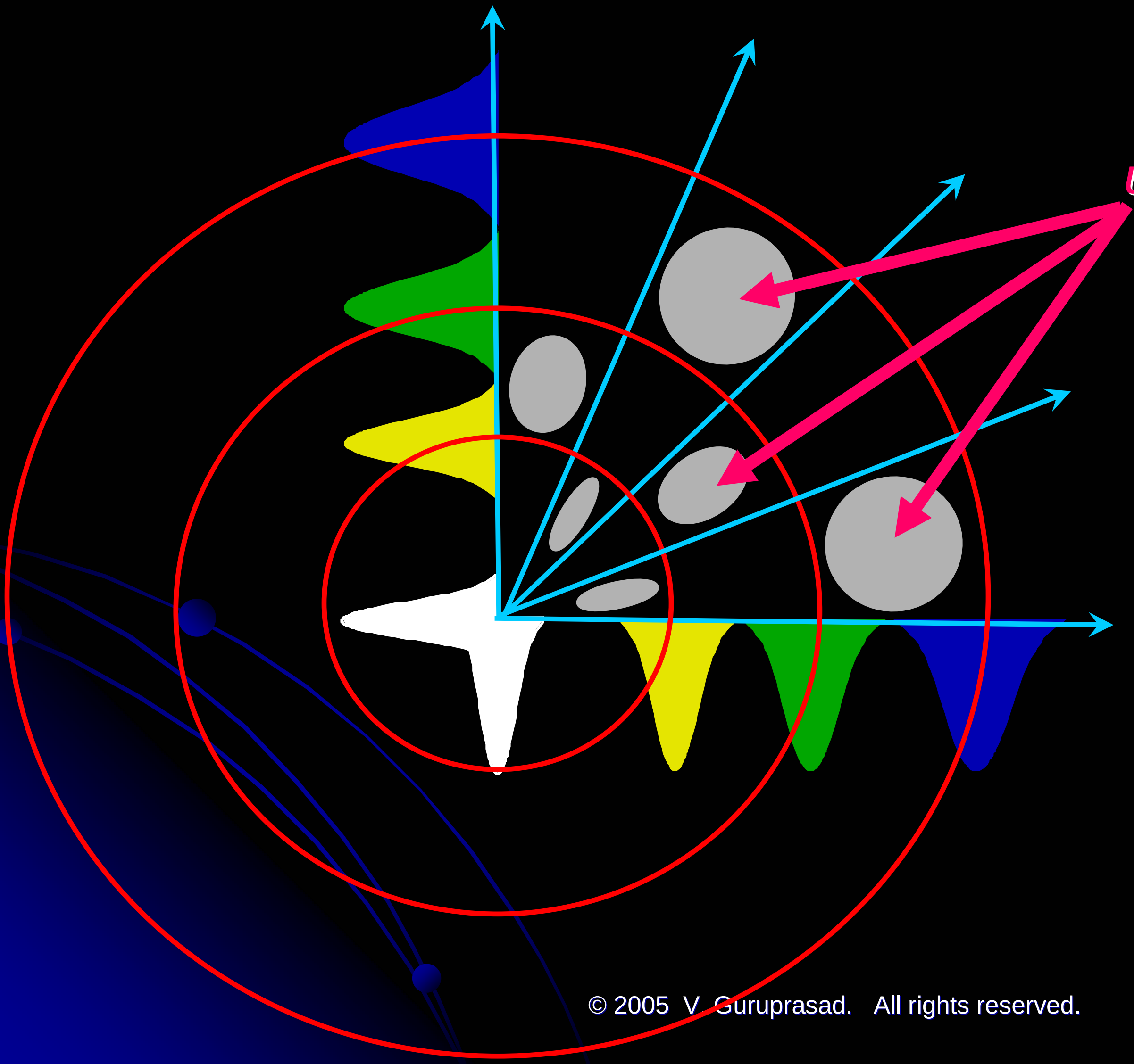
with angle, real SDM



fundamental cells
using “DDM filters”

~~spread spectrum coding~~

~~modulation~~

~~time slicing~~

~~polarization~~

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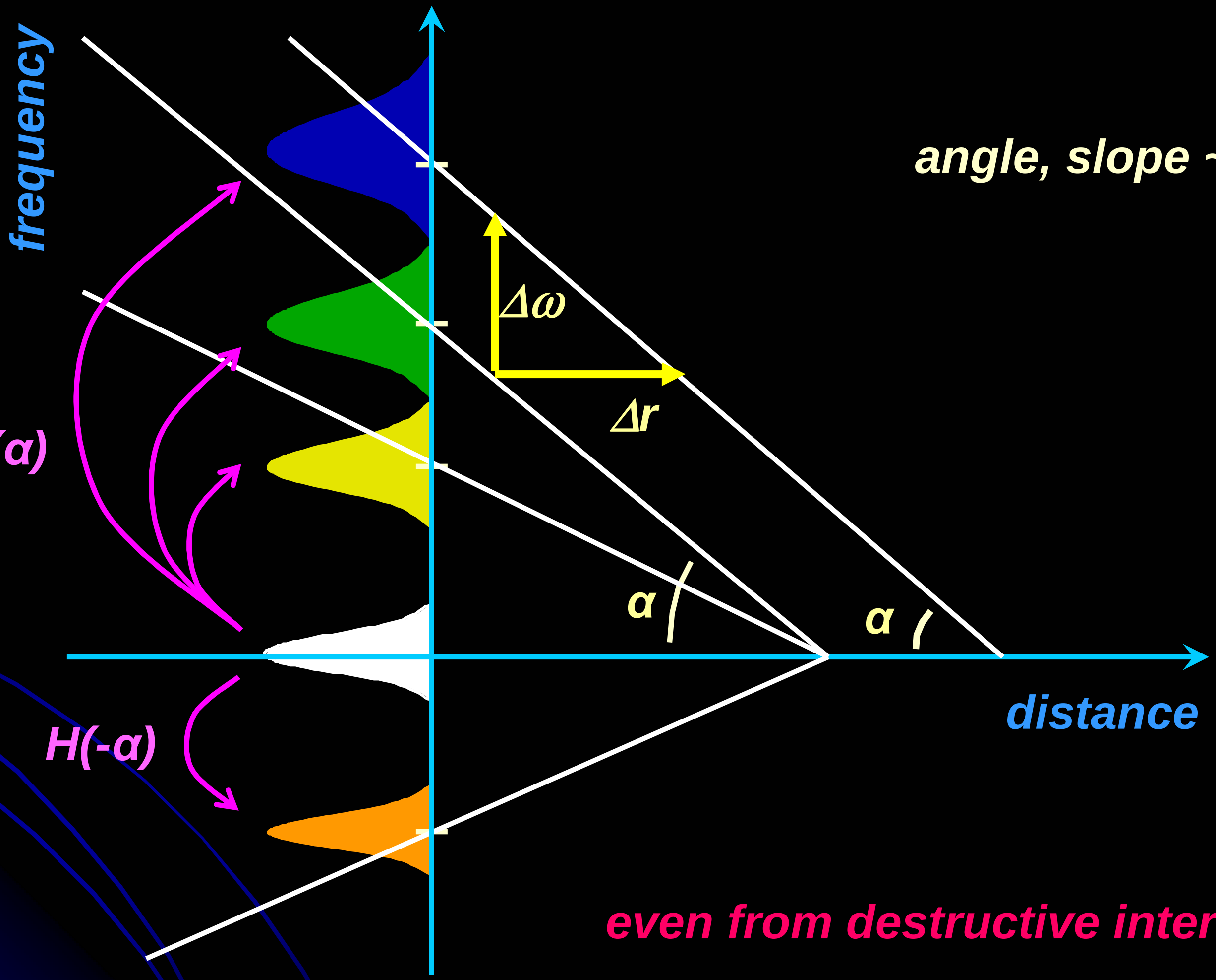
“Hubble separation”



angle, slope ~ parallax

even from destructive interference

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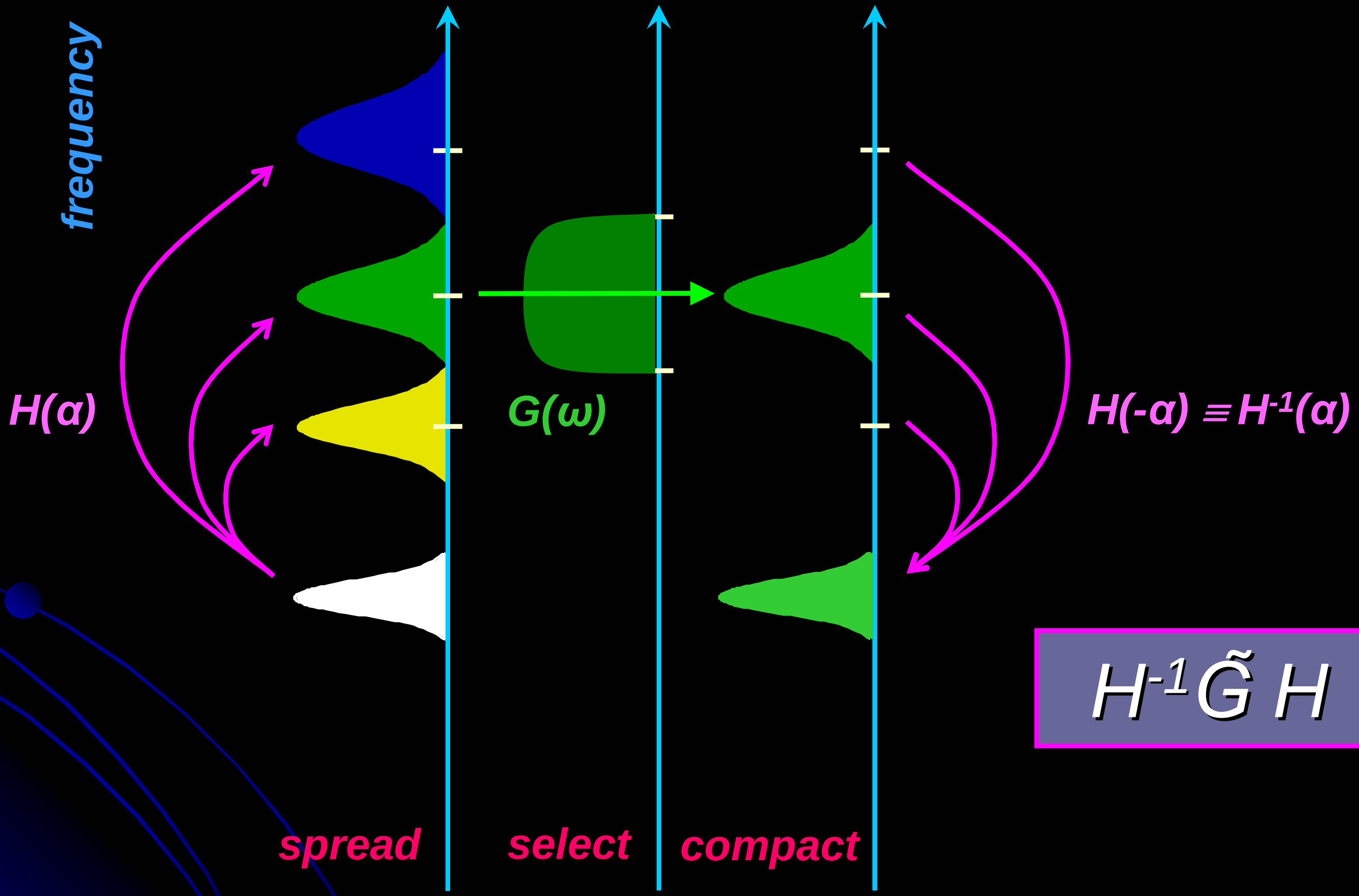
goal

basic “DDM filter”



frequency

$H(\alpha)$

$G(\omega)$

$H(-\alpha) \equiv H^{-1}(\alpha)$

spread select compact

$$H^{-1}\tilde{G}\,H$$

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cosmology is for dreamers

cosmic α_0 too small *and* non linear

$\approx 10^{-18}$ s^{-1} for the most distant galaxies

$\approx 10^{-41}$ s^{-1} at 1 AU ~ earth's orbit

$= 0$ at $r = 0$ – *Einstein-deSitter*

no inverse for H^{-1}

need larger, *receiver-controlled α*

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a terrestrial occurrence

is mandated by solid state physics

gravitational compressive stress + tidal action

plasticity of all solids ~ telescopes, clocks

low stress limit creep rate ~ dislocation work function

$$\boxed{\exp[\, k_B * 1\mathrm{eV} / 300\mathrm{K}\,] \sim O(10^{-18})\ \mathrm{s}^{-1}}$$

extremely slow, weak

half-life ~ age of solar system, universe

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but exactly accounts for

Hubble “flow” and acceleration (*no dark energy*)

10^{-18} s^{-1} ≈ 70 km/s per Mpc (mega parsec)

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but exactly accounts for

Hubble "flow" and acceleration	(*no dark energy*)
NASA's anomalous "accelerations"	Pioneer 10/11, Galileo

in *all six deep space missions equipped for precision ranging*

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but exactly accounts for

Hubble "flow" and acceleration	(*no dark energy*)
NASA's anomalous "accelerations"	Pioneer 10/11, Galileo
5× mismatch tidal coefficients	lab. & space (since '70s)
past expansion of Earth puzzle	geology + paleontology ('60s)

[Kurt Lambeck (1977), Paul Wesson (MS thesis, 1973)]

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better fit than any prior theory

Hubble "flow" and acceleration	*large scale, 15 Gy ≈ 10^{17} m*
NASA's anomalous "accelerations"	*solar system, 1-40 AU ≈ 10^{12}m*
5× mismatch tidal coefficients	*lunar scale, ≈ 3.8×10^{8} m*
past expansion of Earth puzzle	*plate tectonics ~ 10^{7} m*

perfect empirical fit on *every measured scale*

(relativistic cosmology broken at both extremes!)

resolves long pending mysteries – but purely mundane

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about cosmic microwaves…

astrophysics has MORE basic problems

diffraction analysis limited to Fresnel

also in quantum field theory

questions current ideas of

CMB, dark matter, neutrinos

(recent – Jan 2005 – CMB data in favour)

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earthly motivation

the consistency must mean something … mundane!

some prior work on relativity

- formalism *ignores calibration referents*
- relativity *postulates completely derivable* from referents

usual premise of spectrometric stationarity

- central to all of quantum physics
- even in wavelet analysis, etc.

but *no prior analysis of the distortion* → →

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“new mundane physics”

directly from wave equation

- fundamental, very general
- like Doppler, but *receiver-controlled*

finally addresses

- spectrometric non-stationarity
- ties empirical data together

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remainder of this talk

physical concept & principle

“initial hype” results

prototype status & a couple of lessons

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distance information

ordinary (spatial) parallax

view changes with angle ~ *spatial frequency*

information in wavefront curvature

new notion of *temporal parallax*

view angle concerns *temporal frequency*

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semantics

in *temporal frequency* domain,

where is the wavefront curvature ?

what is equivalent to moving one's head ?

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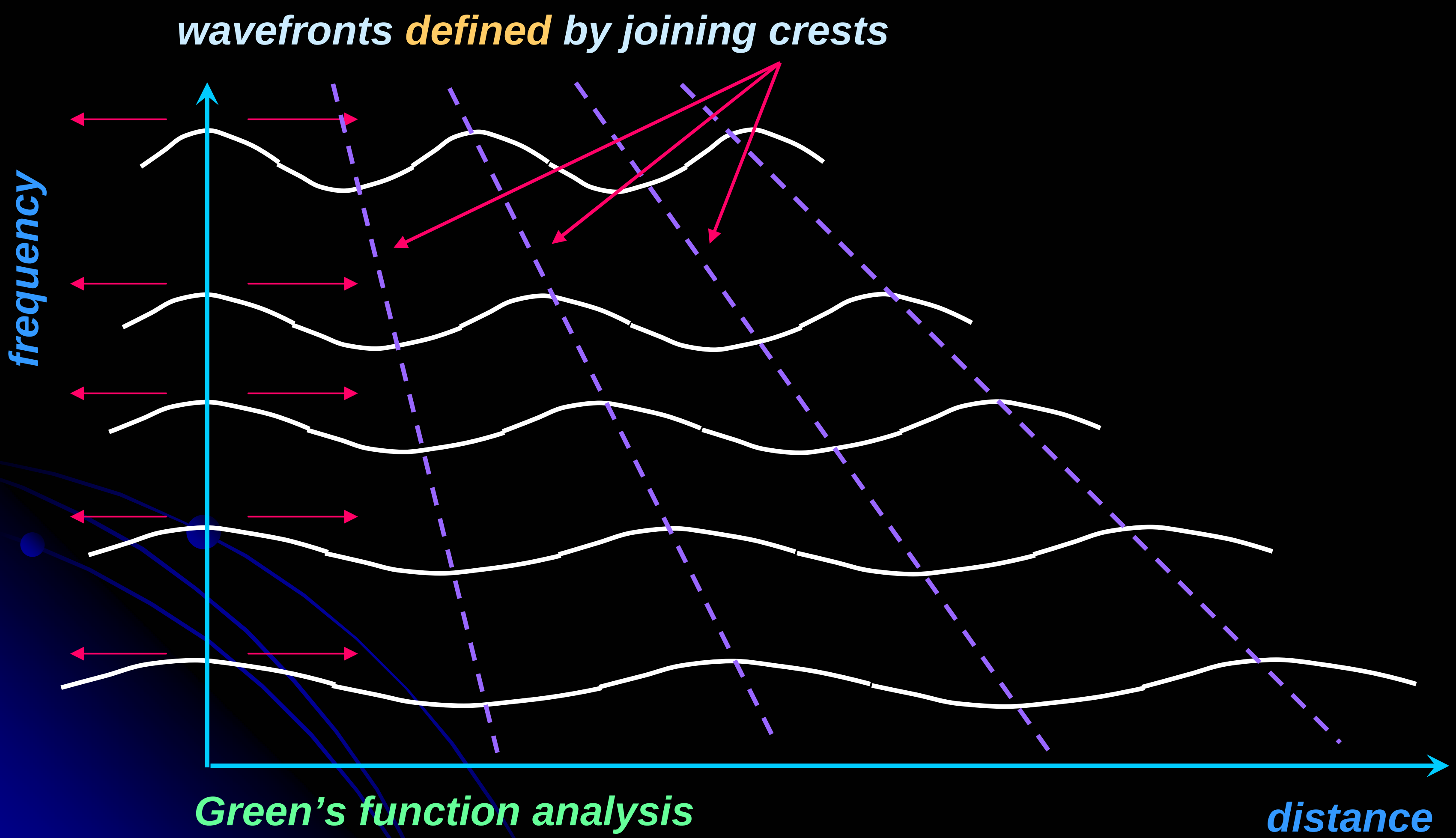
temporal curvature of wavefronts



wavefronts defined by joining crests

frequency

Green's function analysis

distance

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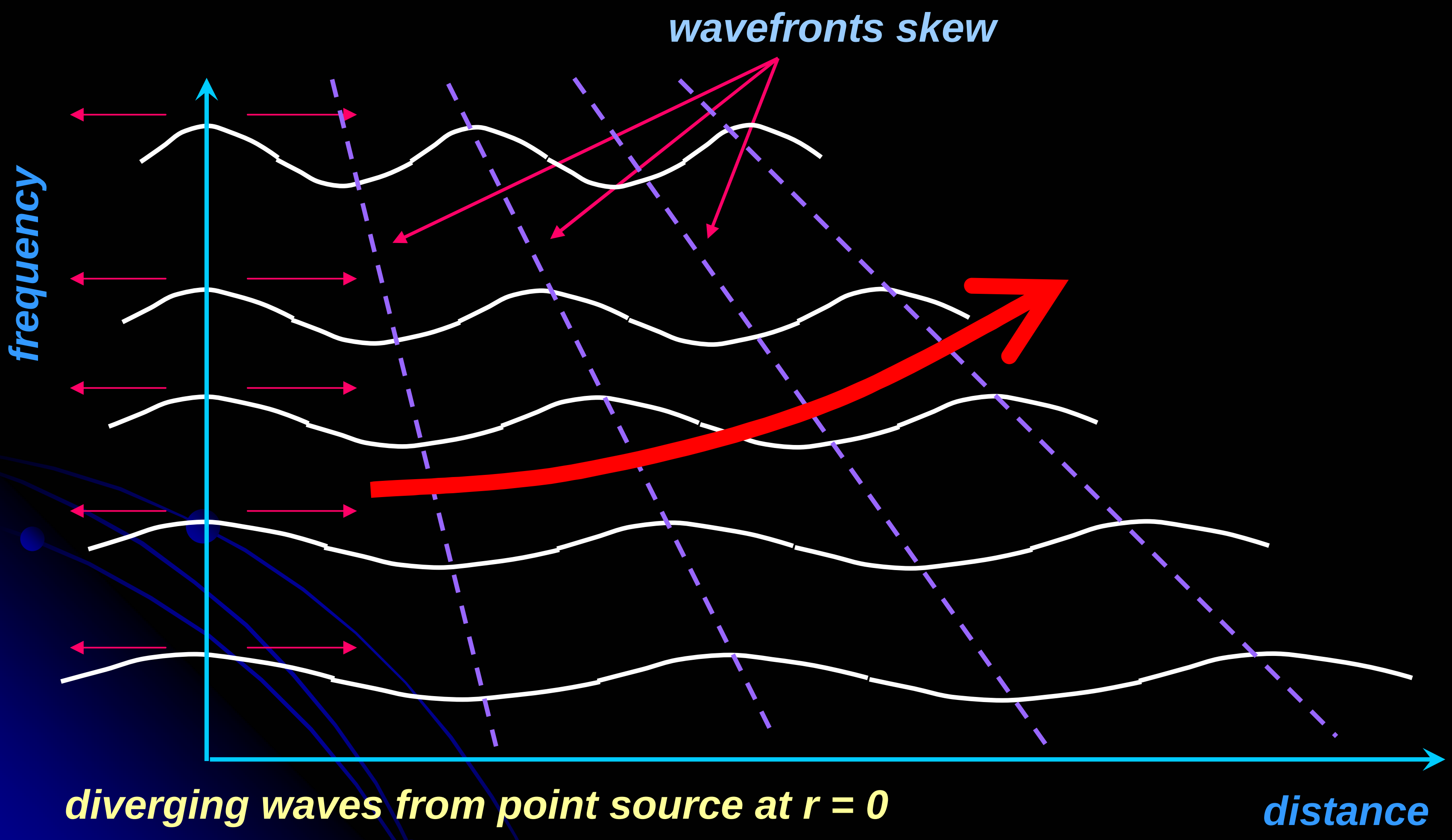
temporal curvature of wavefronts



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measuring phase

coherent reference ordinarily needed

2 levels	digital holography
1 frequency	holography & SAR

must be independent of signal phase

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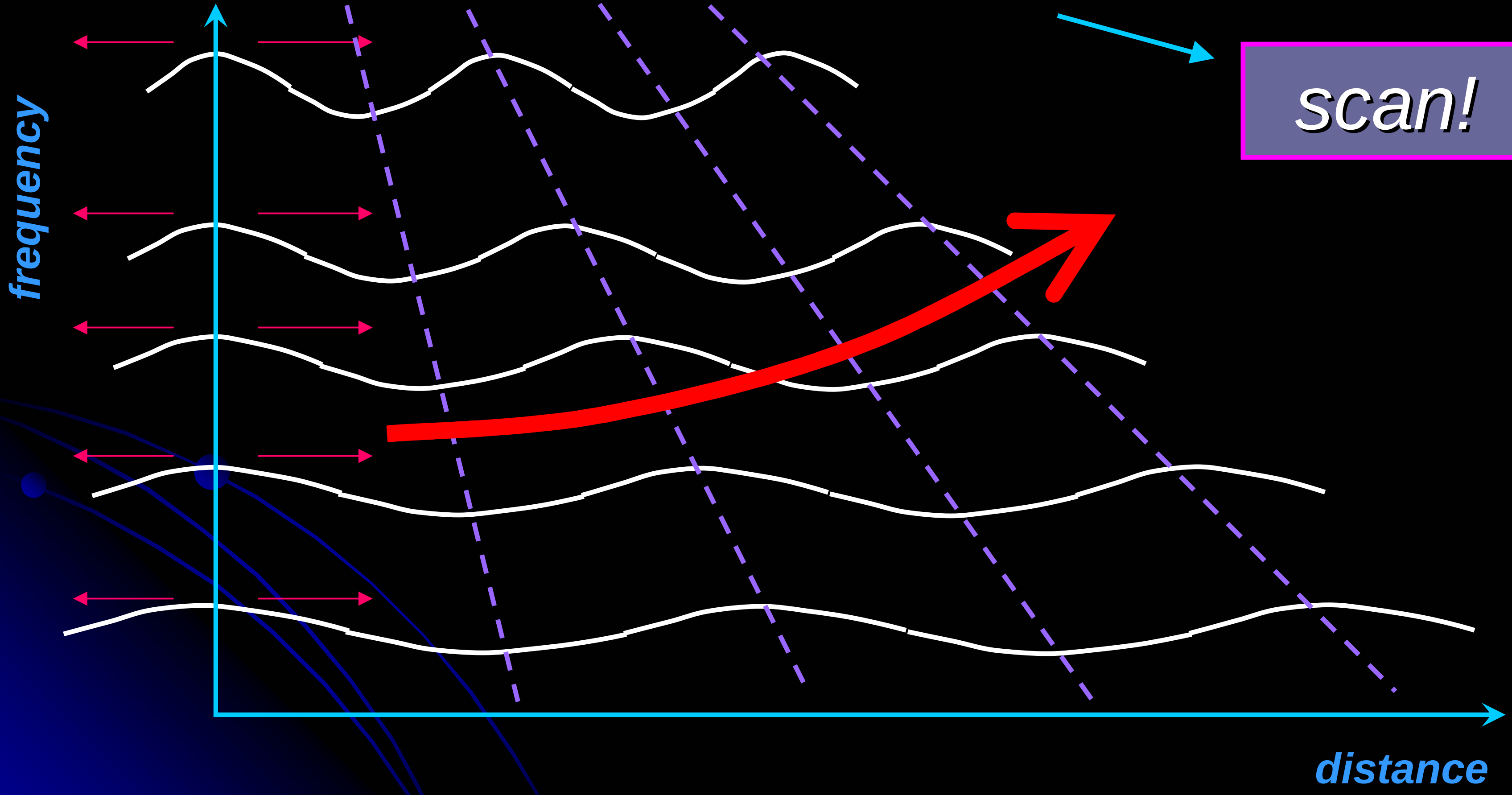
measuring temporal curvature

need only slopes, not absolute phases



scan!

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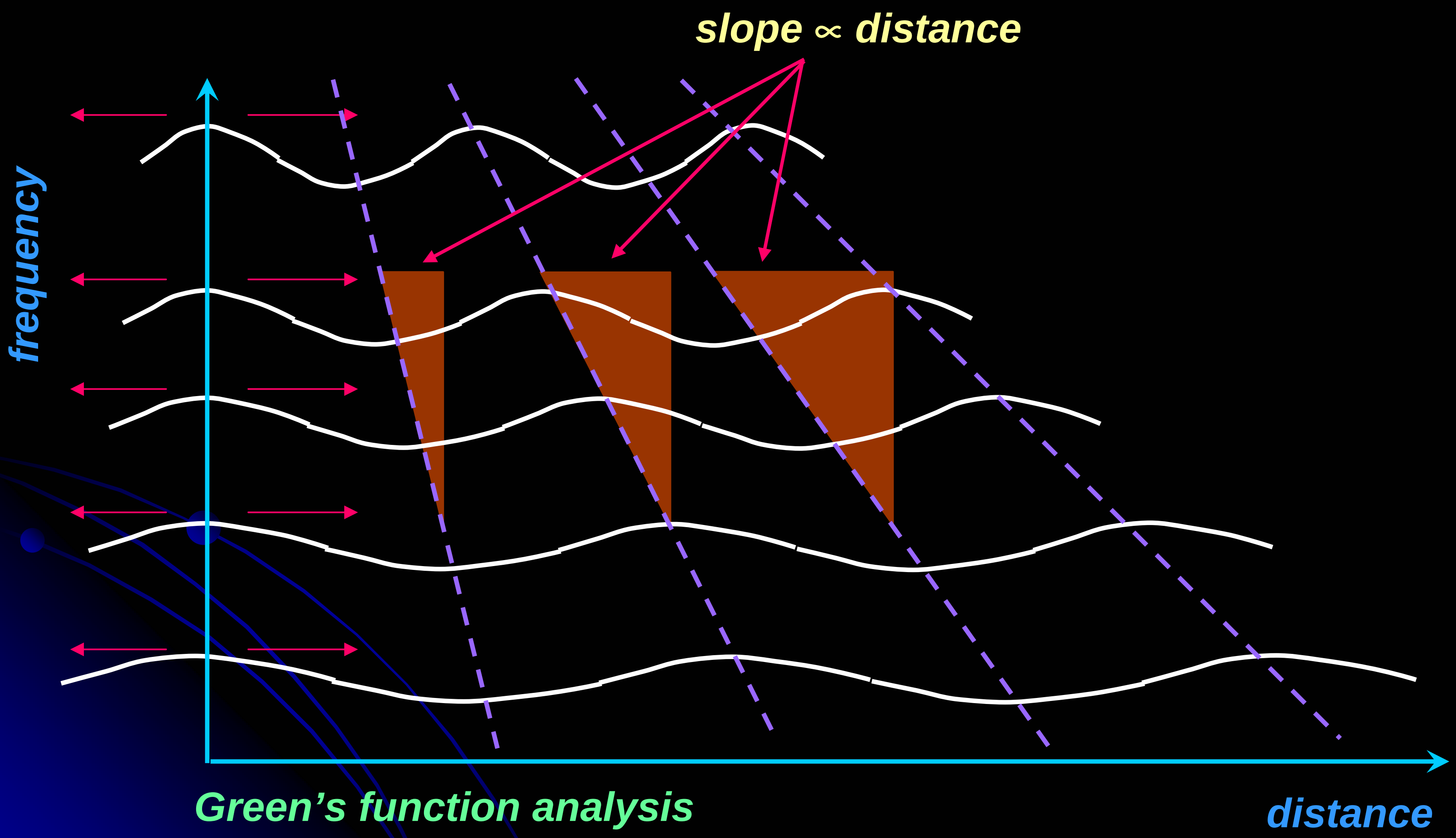
measuring temporal curvature



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so the trick is

measure against RATE of dial turning

transforms phase slope → frequency shift

$$\boxed{\Delta\omega = d\varphi / dt}$$

dial turn rate ~ temporal parallax

temporal equivalent of viewing angle

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wave theoretic analysis

from wave equation

total phase $\varphi = k\,r - \omega\,t$

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wave theoretic analysis

from wave equation

total phase $\varphi = k\,r - \omega\,t$

→ $\Delta\varphi = k\,.\,\Delta r + \Delta k\,.\,r - \Delta\,(\omega\,t)$

last term (time part) = signal

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wave theoretic analysis

from wave equation

total phase $\varphi = k\, r - \cancel{\omega\, t}$

$\Delta\varphi = k\, .\, \Delta r + \Delta k\, .\, r - \Delta\, \cancel{(\omega\, t)}$

ignore signal part $\Delta\varphi = k\, .\, \Delta r + \Delta k\, .\, r$

(for now)

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wave theoretic analysis

from wave equation

total phase

$$\varphi = k\ r - \cancel{\omega\ t}$$

$$\Delta\varphi = k\ .\ \Delta r + \Delta k\ .\ r - \cancel{\Delta\ (\omega\ t)}$$

$$\Delta\varphi = k\ .\ \Delta r + \Delta k\ .\ r$$

---

space part 1st term $\Delta\varphi = k\ .\ \Delta r$

fixed frequency holography, SAR

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wave theoretic analysis

from wave equation

total phase

$$\varphi = k\,r - \cancel{\omega\,t}$$

$$\Delta\varphi = \cancel{k\,.\,\Delta r} + \Delta k\,.\,r - \Delta\,\cancel{(\omega\,t)}$$

$$\Delta\varphi = k\,\cancel{.\,\Delta r} + \Delta k\,.\,r$$

---

space part 1st term $\Delta\varphi = k\,\cancel{.\,\Delta r}$

~~fixed frequency~~ holography, SAR

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wave theoretic analysis

from wave equation

total phase $\varphi = k\, r - \cancel{\omega\, t}$

$$\Delta\varphi = \cancel{k\, .\, \Delta r} + \Delta k\, .\, r - \cancel{\Delta\, (\omega\, t)}$$

$$\Delta\varphi = k\, \cancel{.\, \Delta r} + \Delta k\, .\, r$$

---

space part 2nd term $\Delta\varphi = \Delta k\, .\, r$

fixed distance *~ source*

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wave theoretic analysis

from wave equation

total phase

$$\varphi = k\, r - \cancel{\omega\, t}$$

$$\Delta\varphi = \cancel{k\, .\, \Delta r} + \Delta k\, .\, r - \cancel{\Delta\, (\omega\, t)}$$

$$\Delta\varphi = \cancel{k\, .\, \Delta r} + \Delta k\, .\, r$$

---

no more terms left

→ fundamental in terms of phase information

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resulting wave effect

discrete Δk pulse radar → *limited by aliasing*

continuous scanning $\Delta\omega = d\varphi / dt = r \,.\, dk / dt$

Doppler-like ~ proportional

$\boxed{z = \Delta\omega / \omega = \beta r / c}$ *where* $\boxed{\beta = k^{-1}(dk / dt)}$

measured "z" in astrophysics – well beyond **7**

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realization

Receiver type	*time-varying*
diffractive optics	grating intervals
resonant or tuned systems	tuning element
digital signal processing	sampling interval

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grating approach

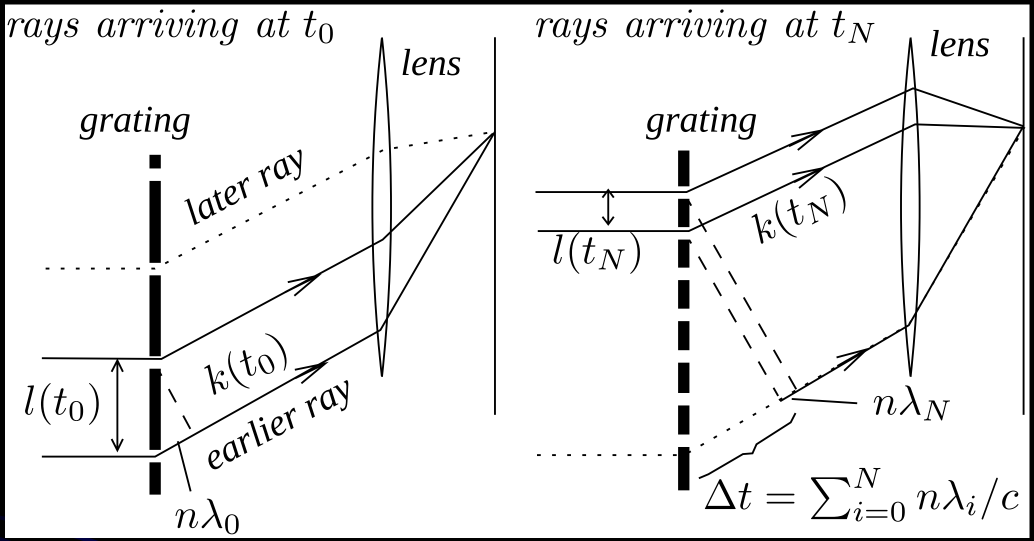
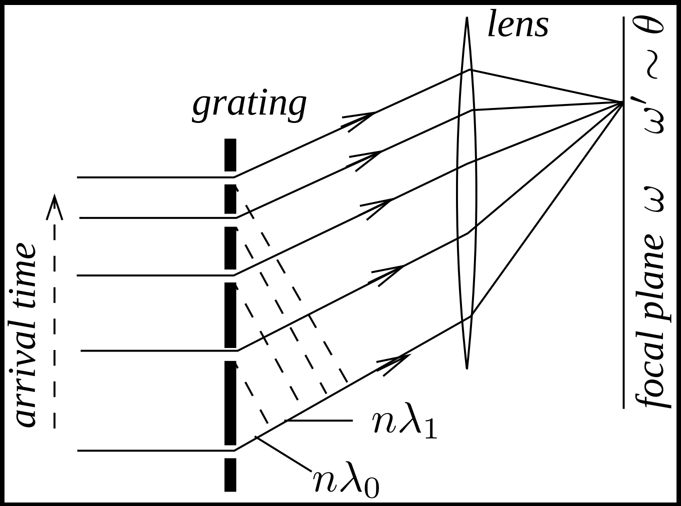


Fig. 3 of paper

Fig. 4 of paper



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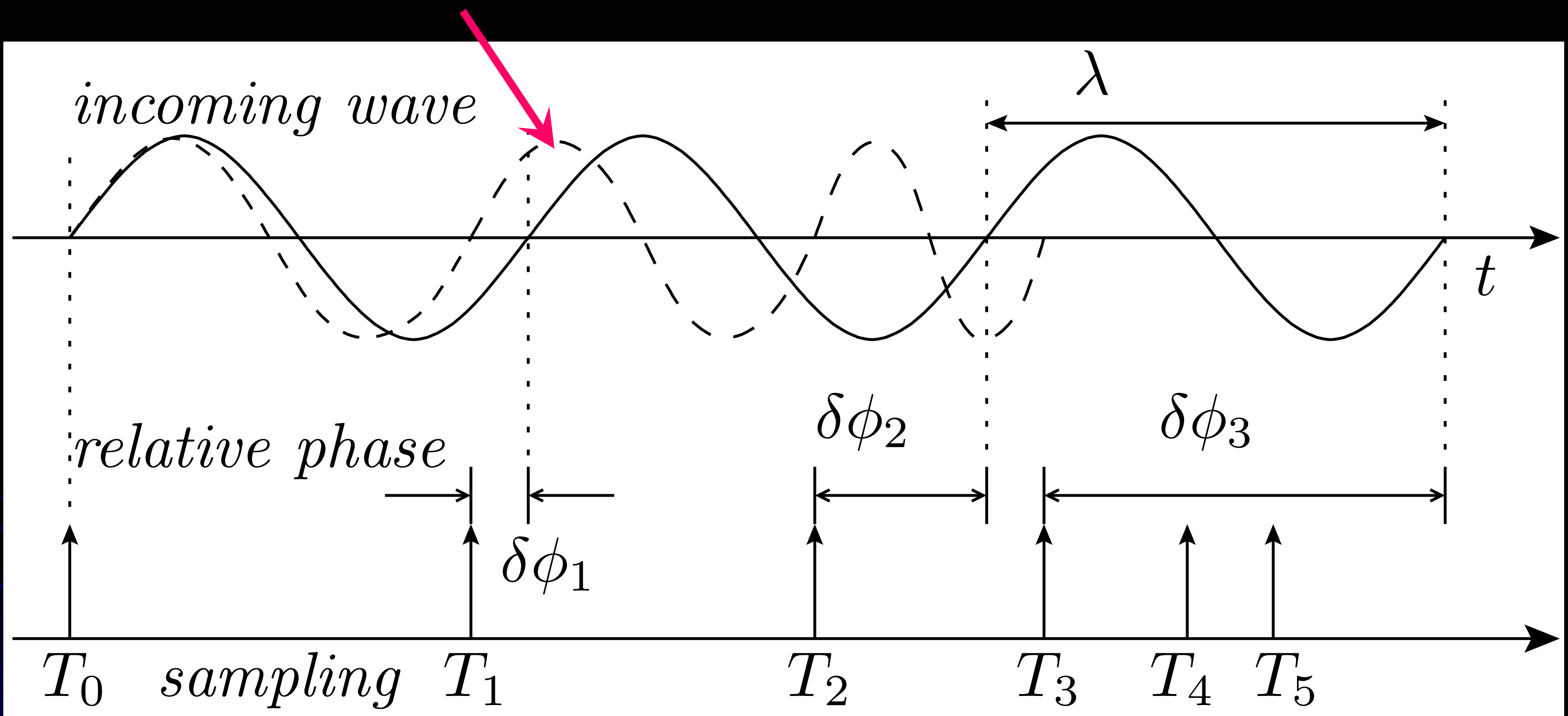
sampling approach



sampling eigenfunction

Fig. 5 of paper

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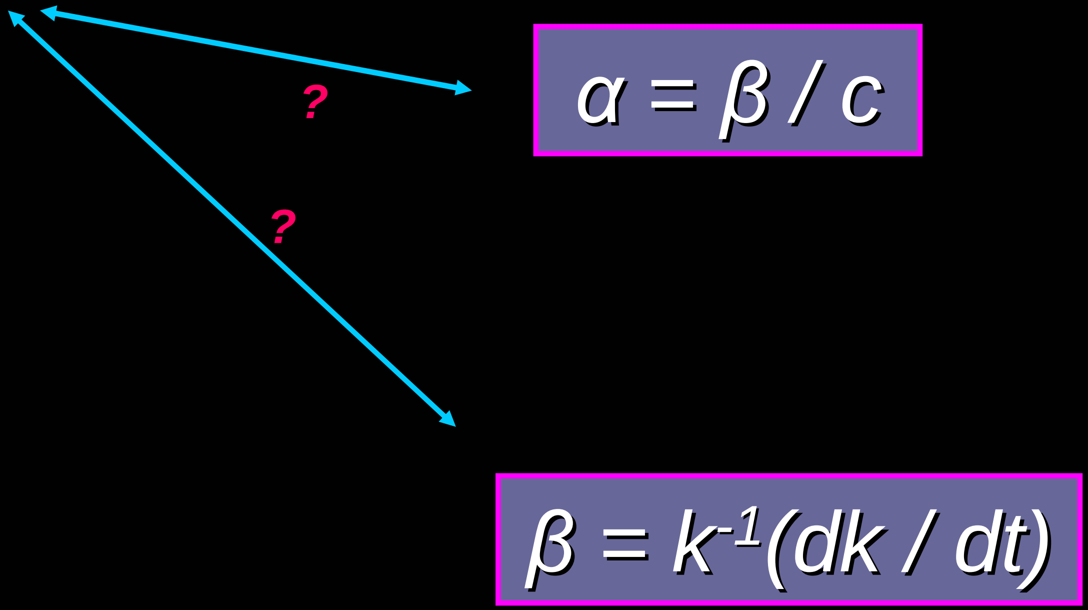
time-varying eigenfunctions

$$\exp[\, kr \pm \omega t / a(t) \,] \equiv \exp[\, a(r)\, kr \pm \omega t \,]$$



$$\alpha = \beta / c$$

$$\beta = k^{-1}(dk / dt)$$

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time-varying eigenfunctions

$\exp[\, kr \pm \omega t / a(t) \,] \equiv \exp[\, a(r)\, kr \pm \omega t \,]$

- L. Parker's 1966 PhD thesis in cosmology
  - a ~ *relativistic scale factor*

$$\boxed{\beta = a^{-1}(da / dt)}$$

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time-varying eigenfunctions

$\exp[\, kr \pm \omega t / a(t) \,] \equiv \exp[\, a(r)\, kr \pm \omega t \,]$

L. Parker's 1966 PhD thesis in cosmology

a ~ relativistic scale factor

$\boxed{\beta = a^{-1}(da / dt)}$

a(t) ~ receiver's **scale of frequencies**

receiver's view spatially distorted as a(r)

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time-varying eigenfunctions

$\exp[\, kr \pm \omega t \,/\, a(t) \,] \equiv \exp[\, a(r)\, kr \pm \omega t \,]$

L. Parker's 1966 PhD thesis in cosmology

a ~ relativistic scale factor

$\beta = a^{-1}(da \,/\, dt)$

a(t) ~ receiver's **scale of frequencies**

receiver's view spatially distorted as a(r)

receiver's decomposition is mathematical

fundamental : not a postulate or result of physics

$a(r) \equiv a(t)$ from the wave equation

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principle of receiver decomposition

choice belongs to receiver

receiver sums successive λ's

"Parker" if λ's vary

requires real signals – $\Delta\omega \neq 0$

like the natural occurrence…

fundamentally changes photon theories

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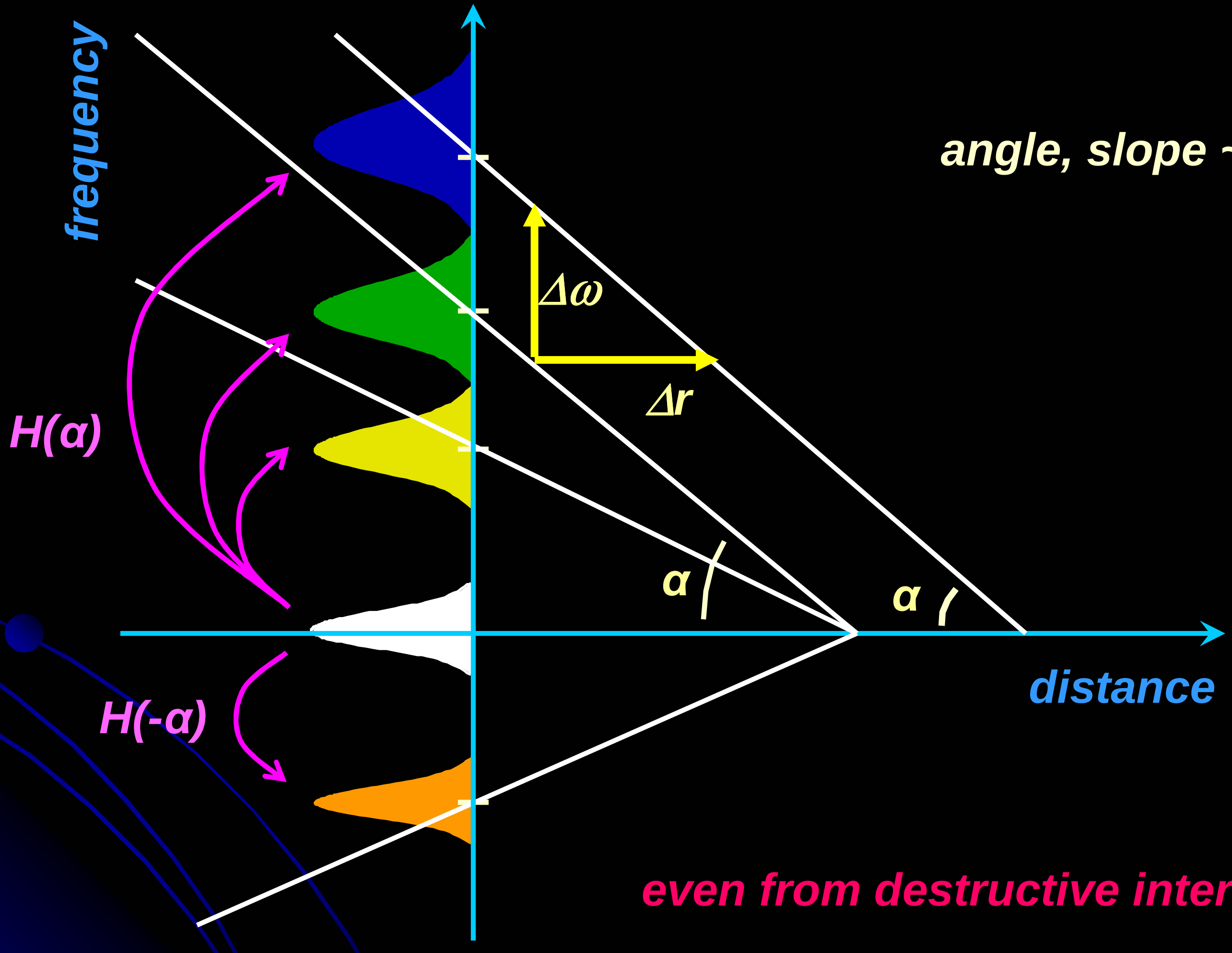
thus temporal parallax



angle, slope ~ parallax

even from destructive interference

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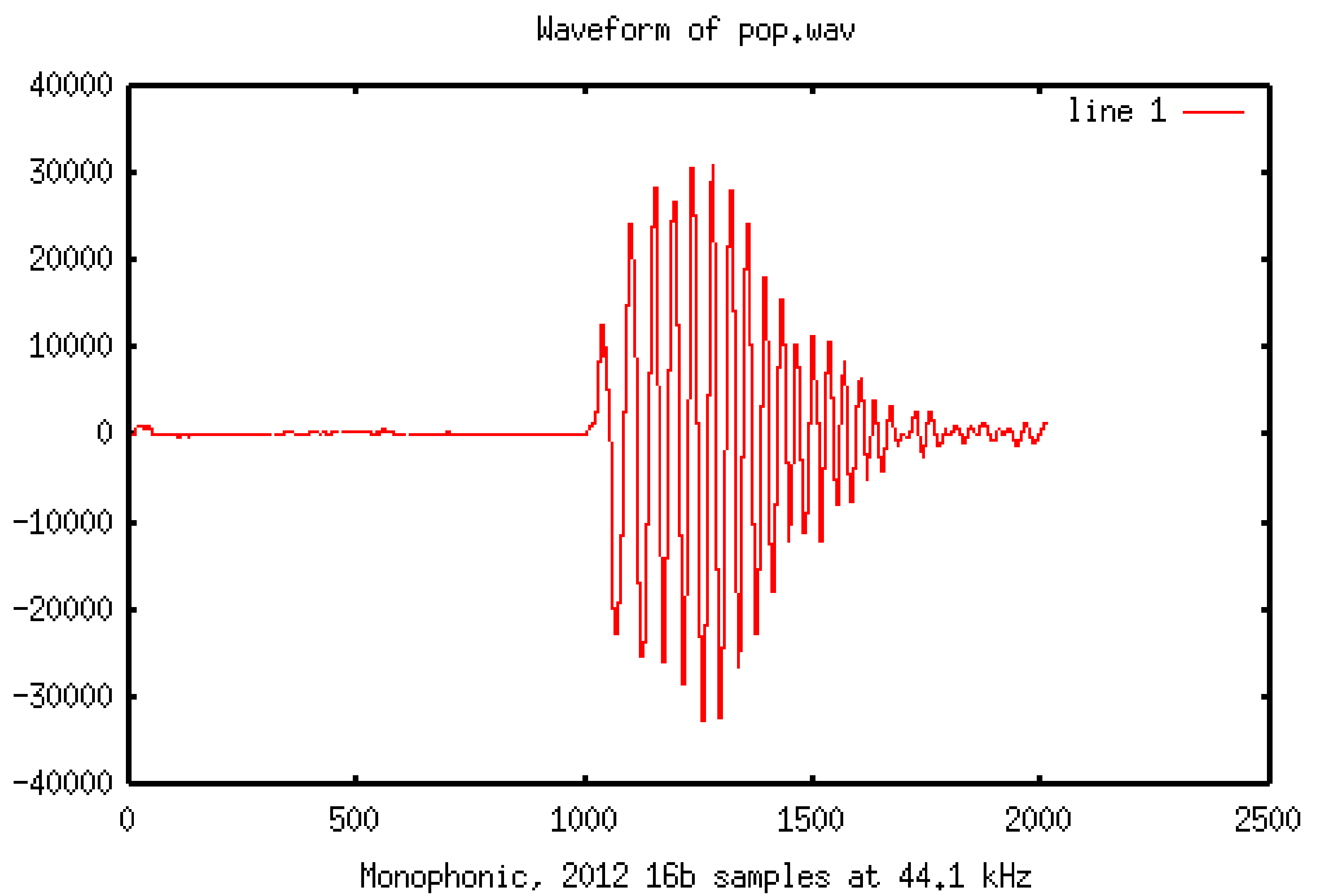
initial example (from paper)



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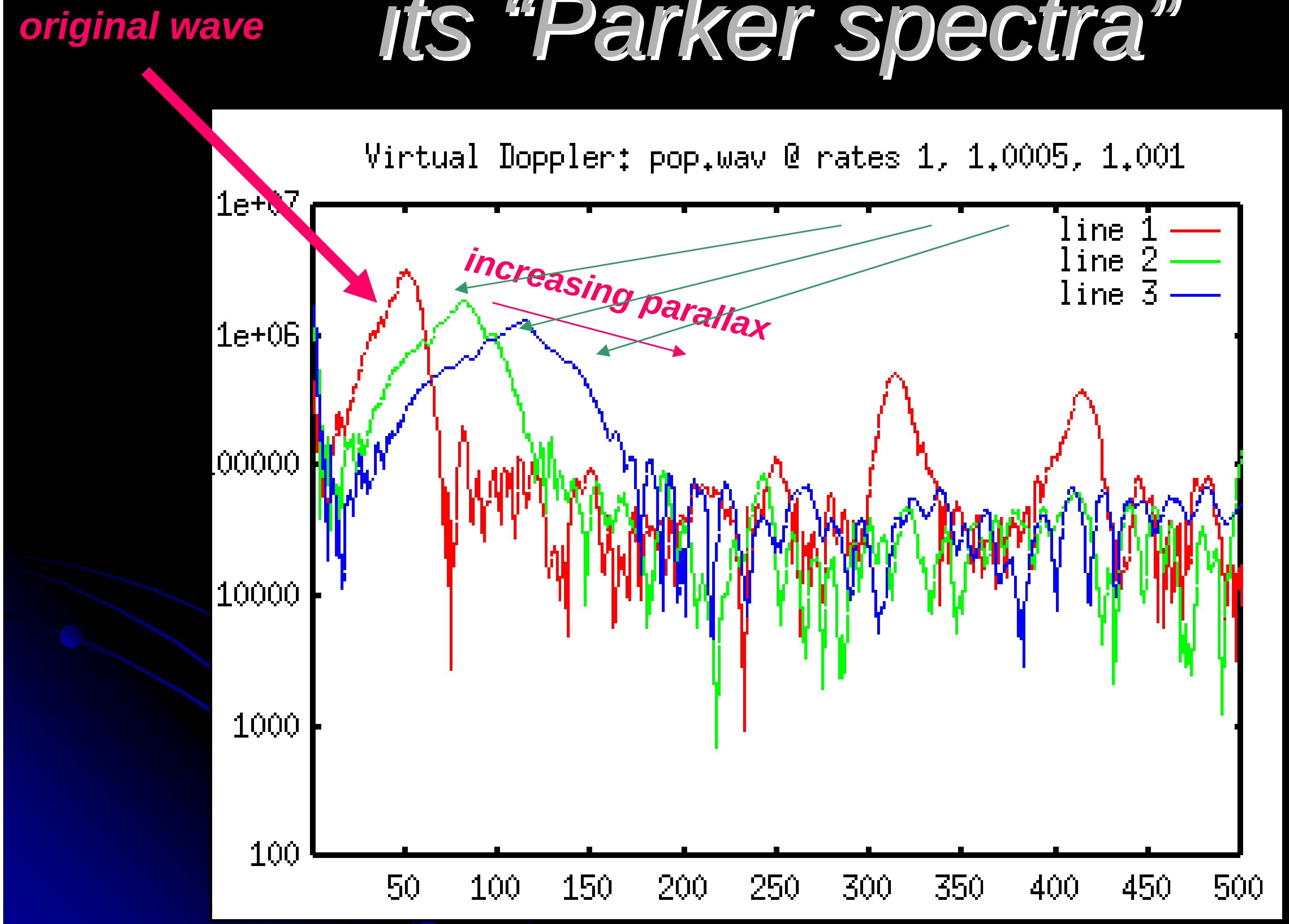
its "Parker spectra"



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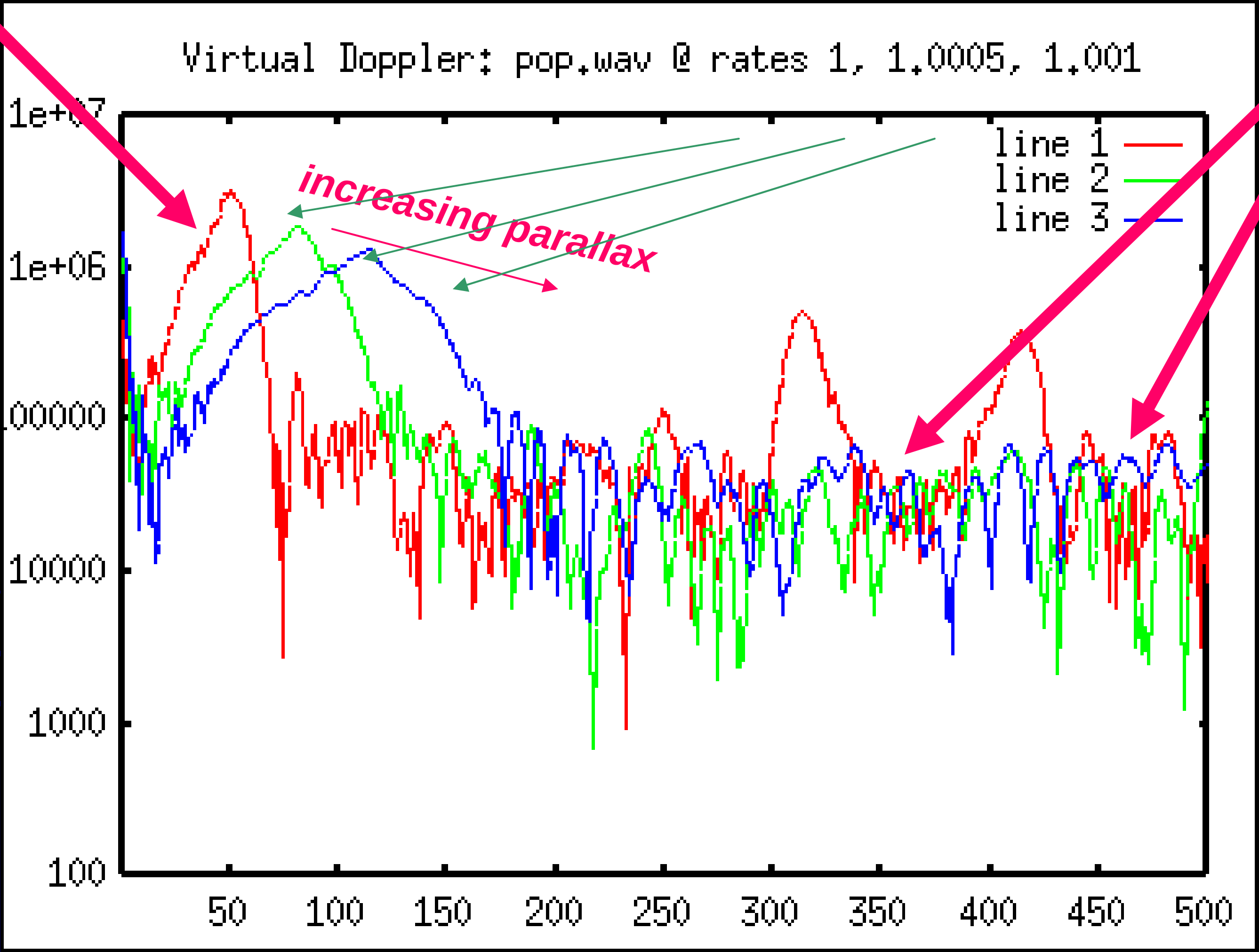
its “Parker spectra”

original wave

interpolation loss



increasing parallax

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java prototype

simple design console

test of "DDM filters"	$H^{-1}\tilde{G}\,H$ operators
Remez algorithm	filter design ($\tilde{G}$)
test of assumptions	

envisage easily portable

to Software-Defined Radio, MAC layers

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lessons from simulation

orthogonality ≠ Fourier

applying *H* to generated sinusoids gives scarily bad results

must simulate source with $\Delta\omega > 0$ ("Parker" orthogonality)

ω-scanning mixes with signal

current area of work – should be easy to solve

"textbook DSP" is deceptive

may be necessary to use spatial spread ~ grating approach

must really really *try with* real *data*

other audio samples not so lucky ~ back to the drawing board!

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known limits

no fundamental limits

- the Big Bang corresponds to *z = infinity*
- *$\alpha > 0$*

technology limits

- limits of sampling, DSP – e.g. simulation woes
- must use RF – *IF separation will be poor*
- phase distortions in antenna, processing
- angular resolution of phased arrays
- filtering limits – stop-band rejection (*G*)

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conclusion – or beginning?

a new basic wave effect shown

with commensurate broad implications

must try with real data

unless totally mistaken…

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SIM TIME!

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