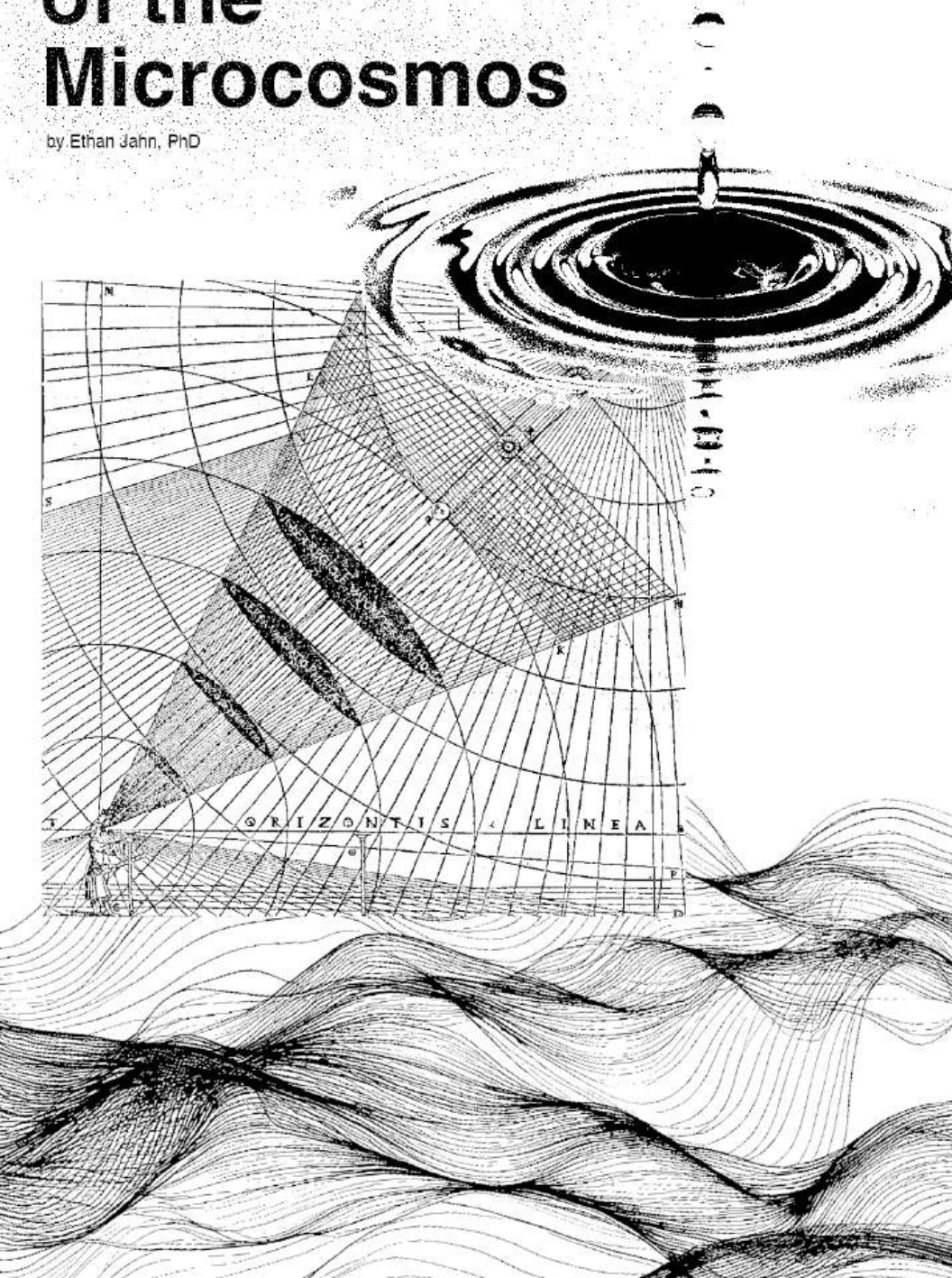


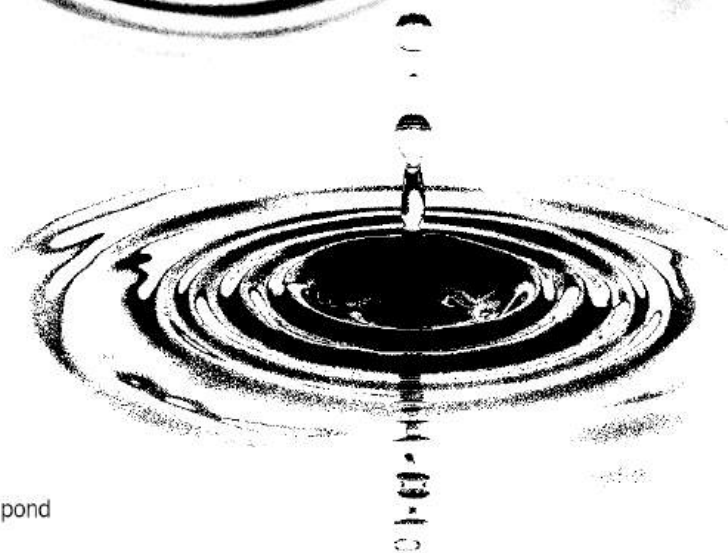
Macrostructures of the Microcosmos

by Ethan Jahn, PhD





a pebble



dropped in a pond



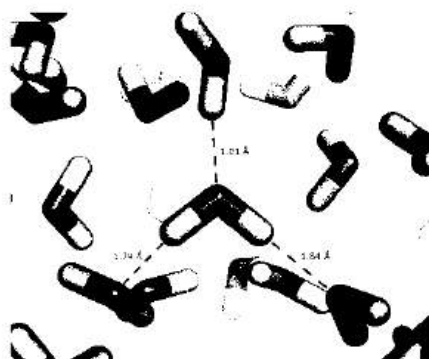
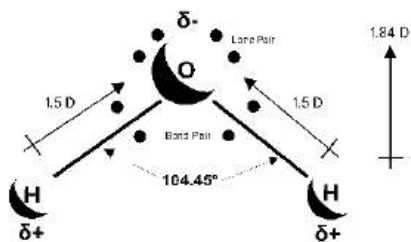


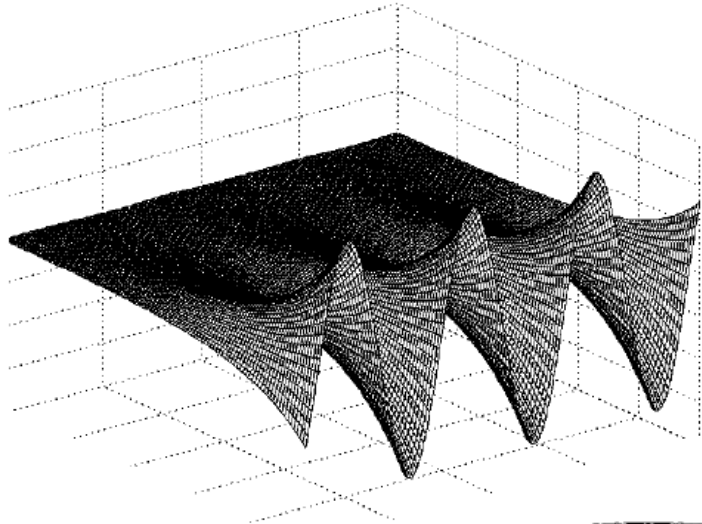
forces between those miniscule

yet monumental

molecular beings

form waves



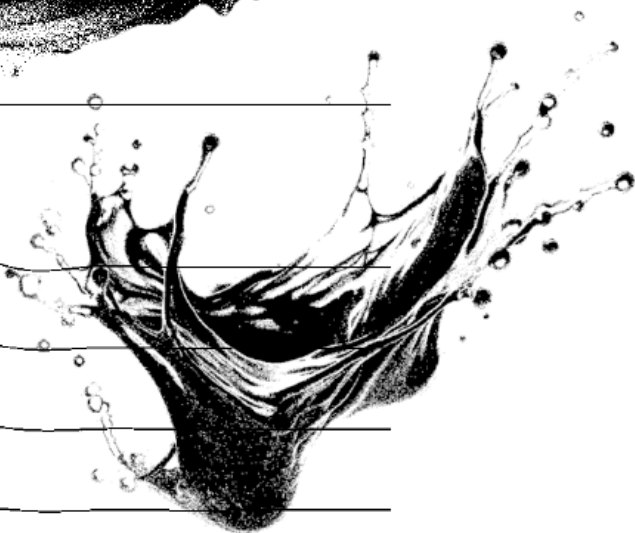
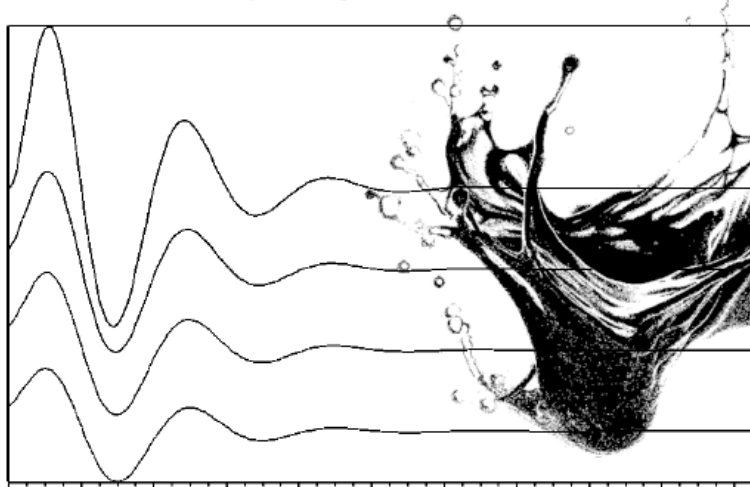
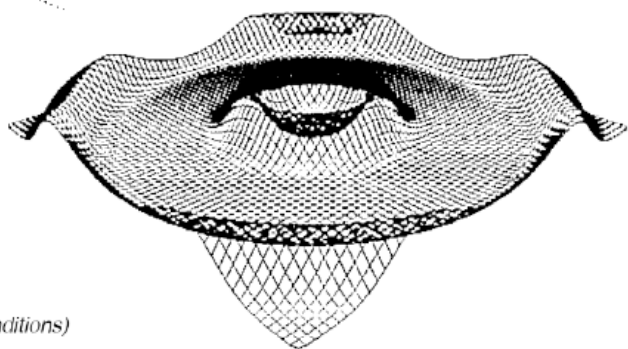


amplitude *(growth)*

period *(waits for)*

velocity *(fertile)*

wavelength *(conditions)*





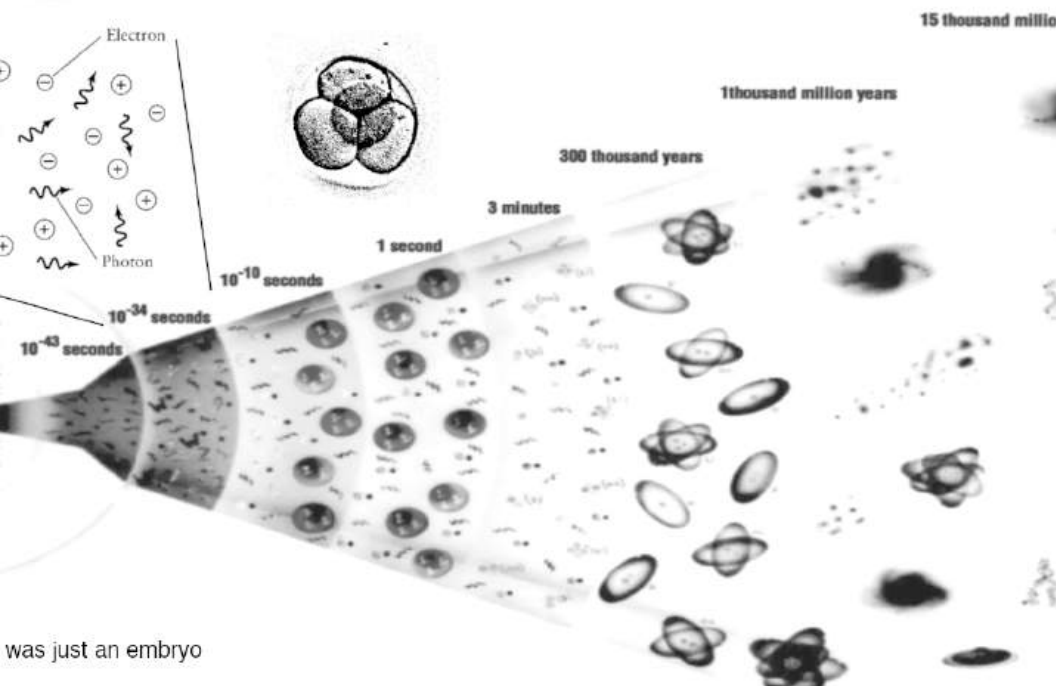
complexity

emerges

from

simple

ingredients



was just an embryo

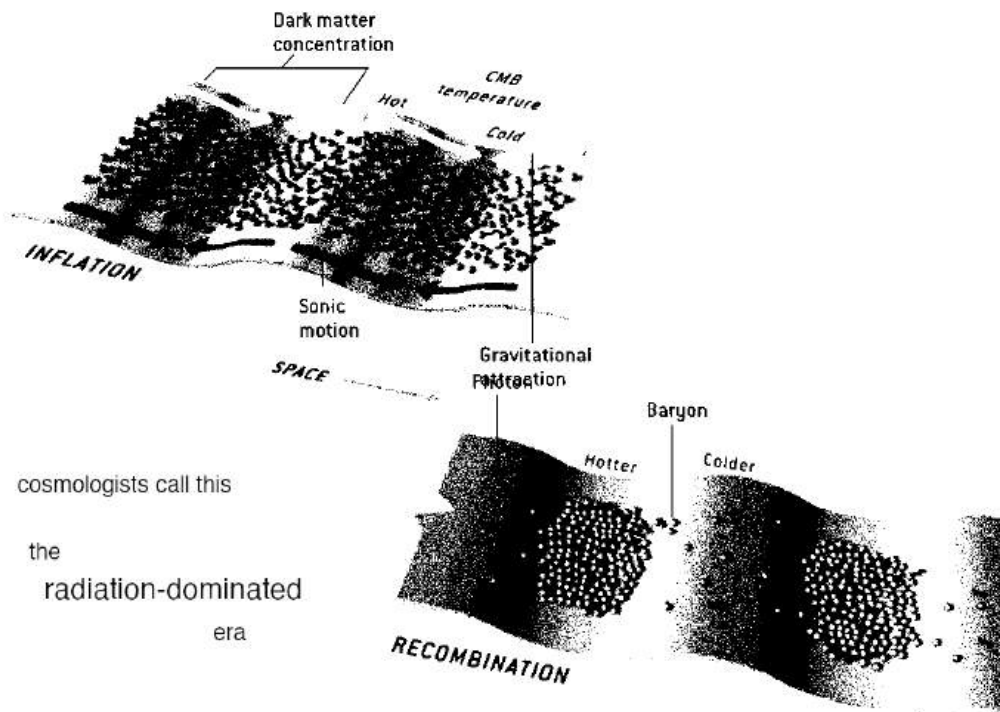
it was tiny, undeveloped,
primitive,
full of potential

is thousands of times more compact than our current universe

all of a hot, dense plasma
made of protons, electrons, and photons

(these are sometimes referred to as baryons)



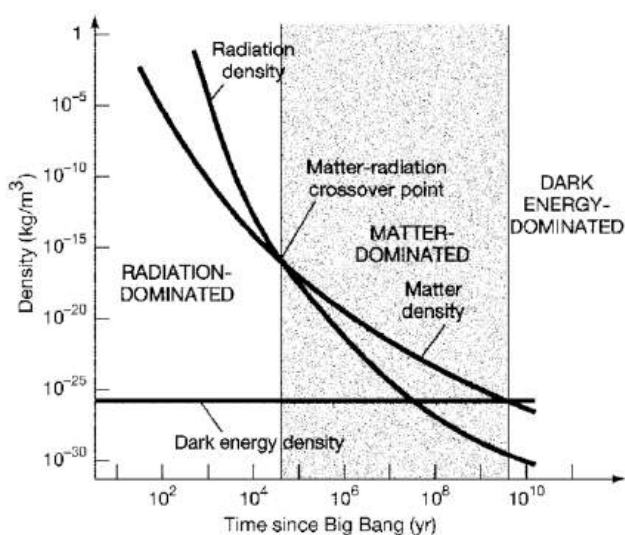


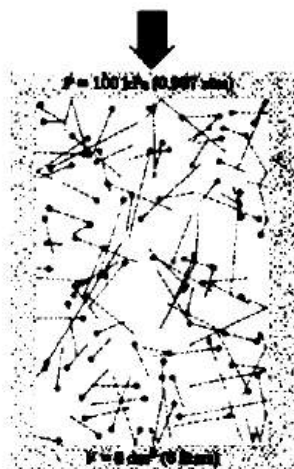
cosmologists call this

the radiation-dominated

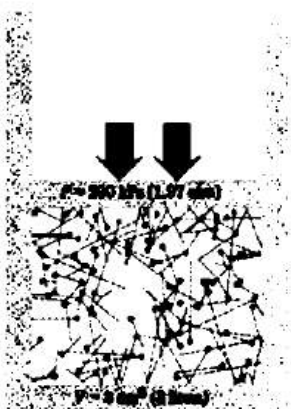
era

when light was more dense than matter

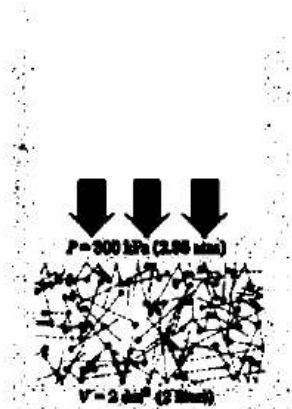




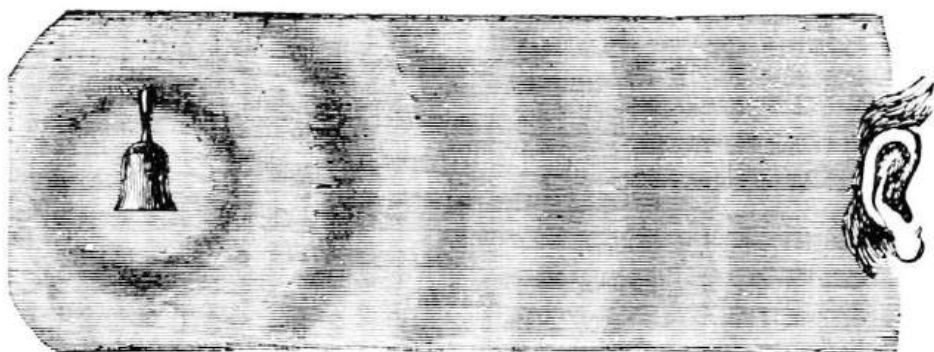
(a)



(b)



(c)



high pressure

low pressure

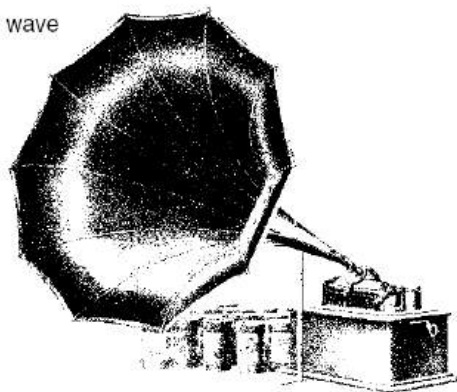
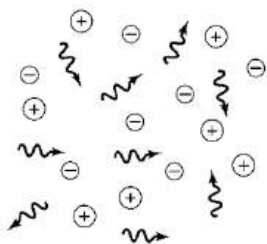
pressure increases when collisions are commonplace

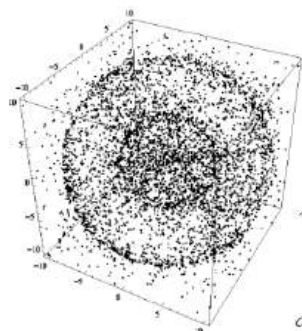
oscillations between compression and rarefaction

travel through space (and time) as a wave

that we call

sound





just
just
like

ripples
ripples

on

||

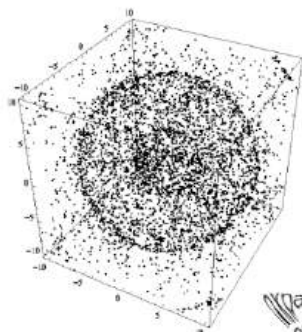
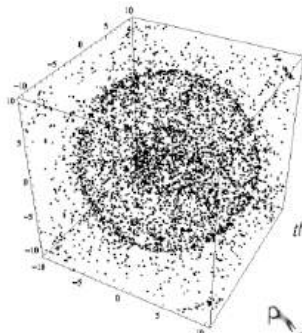
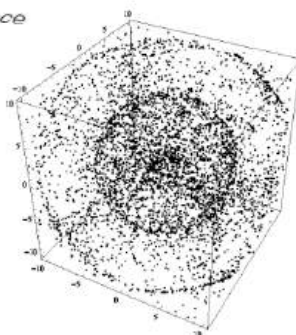
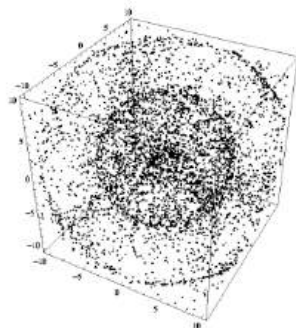
the
one

surface
surface
surface

of

the
the

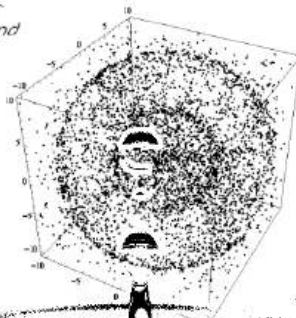
pond
of



sound
sound
sound

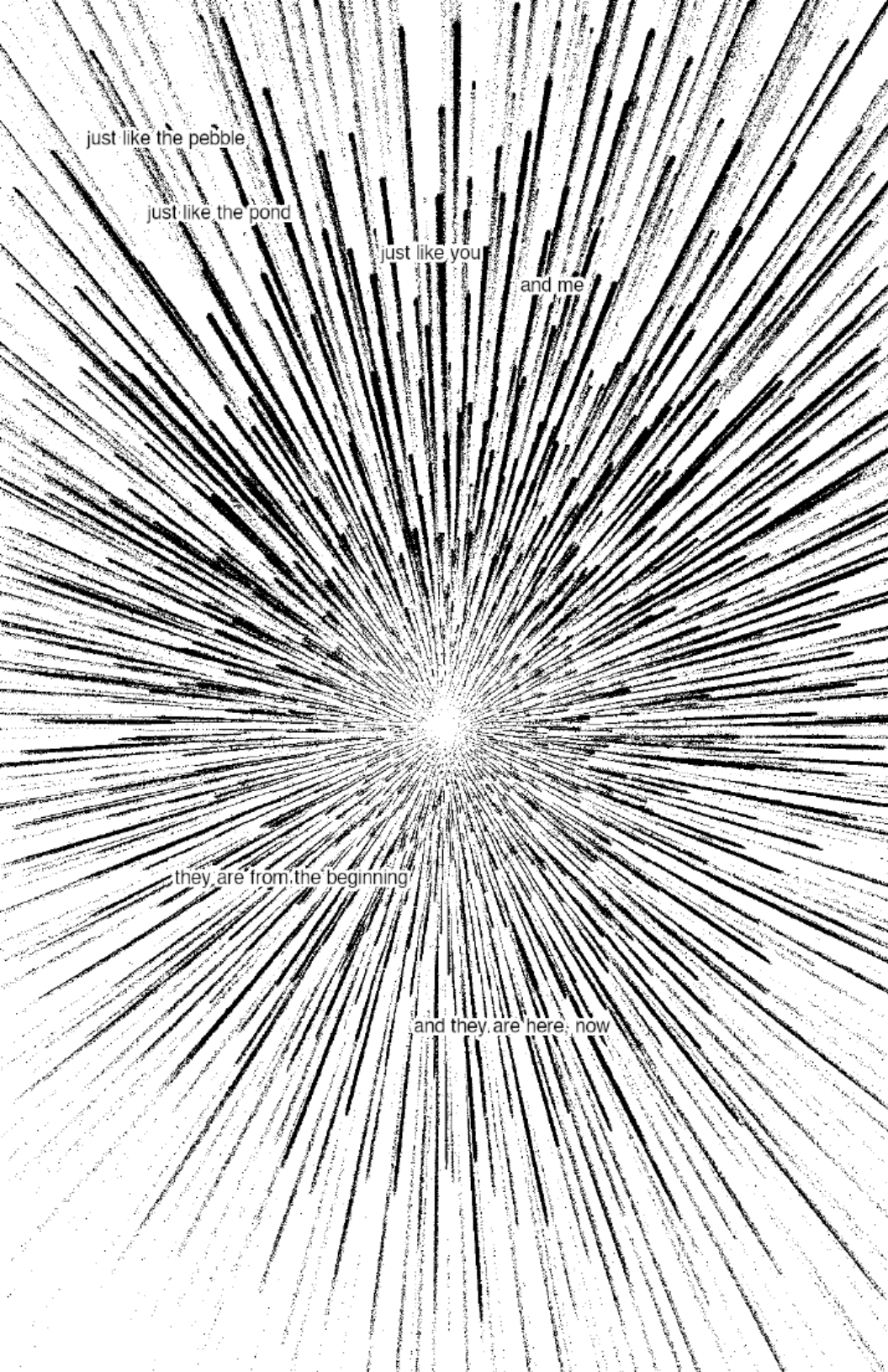
waves
waves

expand
expand
expand



waves
outwards





just like the pebble

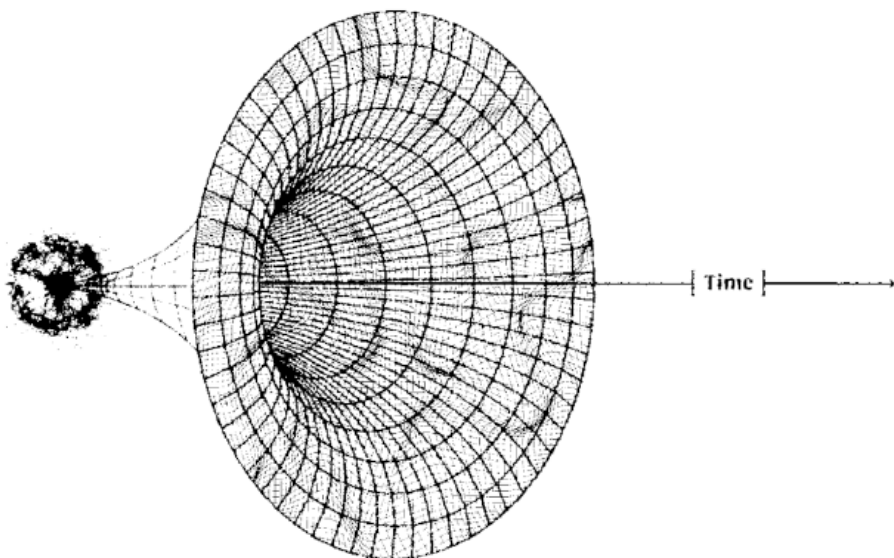
just like the pond

just like you

and me

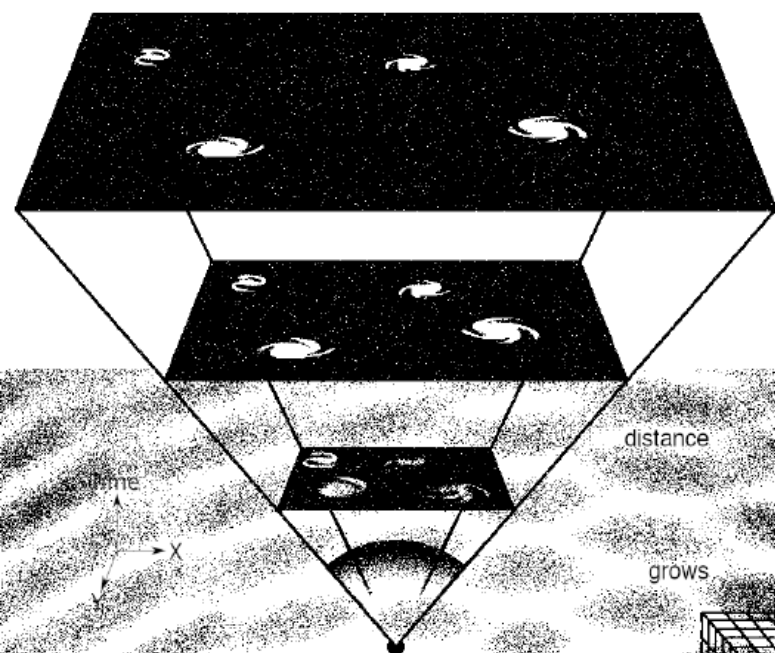
they are from the beginning

and they are here, now



space

expands



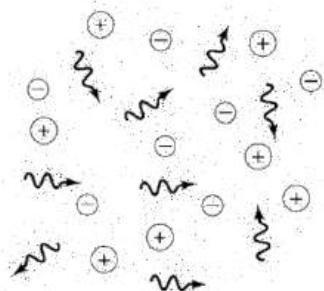
distance

grows

and the waves grow, too

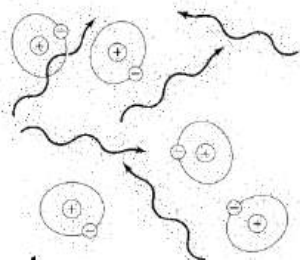


like a cloud dissipating

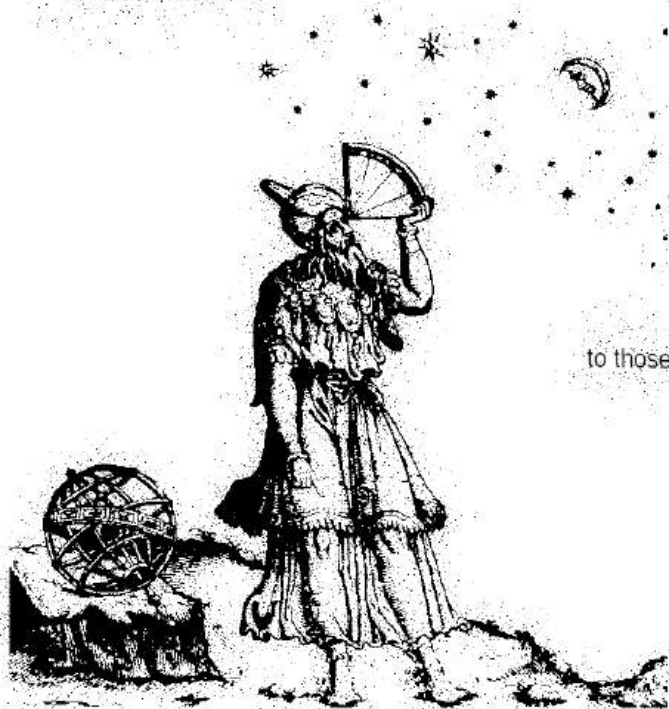


the dense fog of the early universe

becomes clear

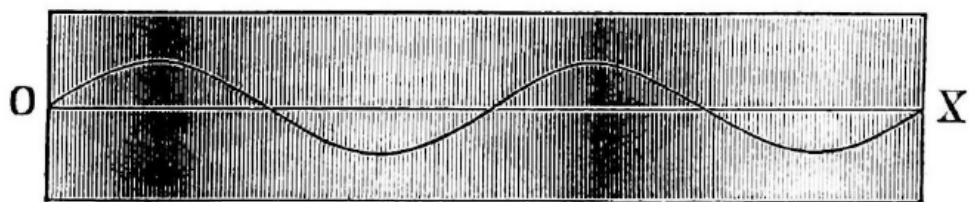


and reveals itself



to those who look



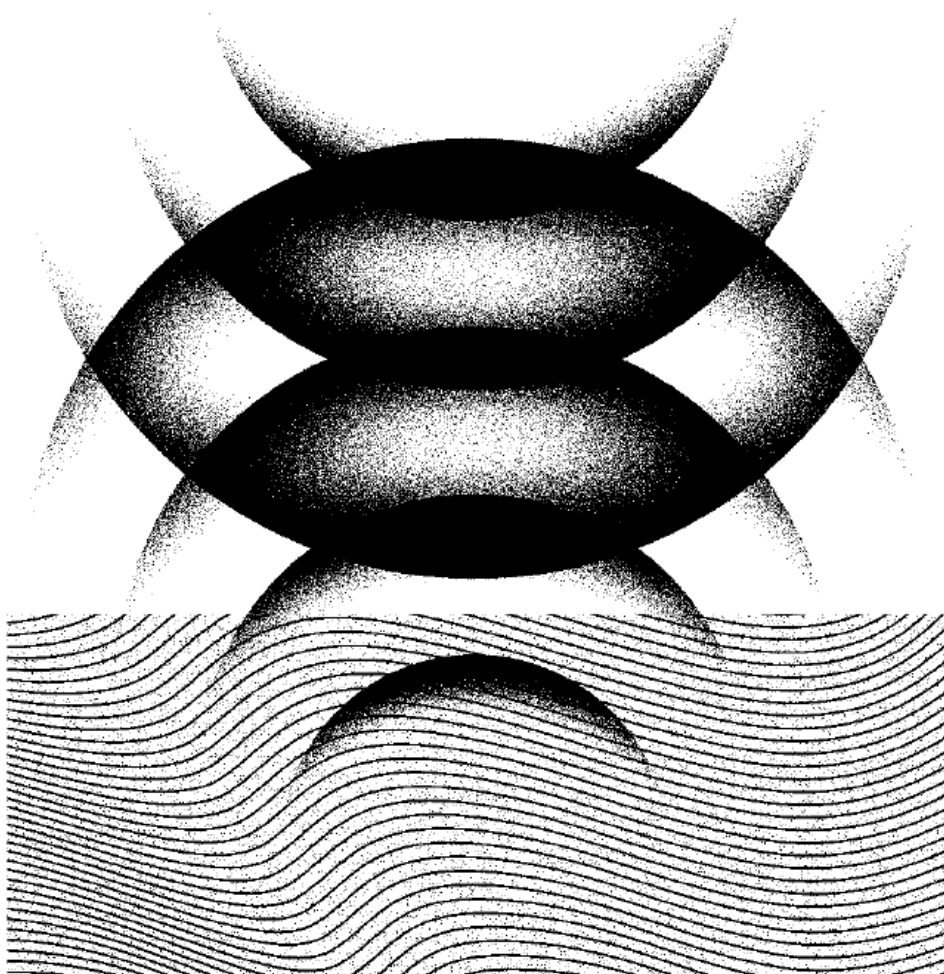


(what) matter(s) becomes frozen in place

the imprint remains

features once too small to notice

become magnified to grand proportions

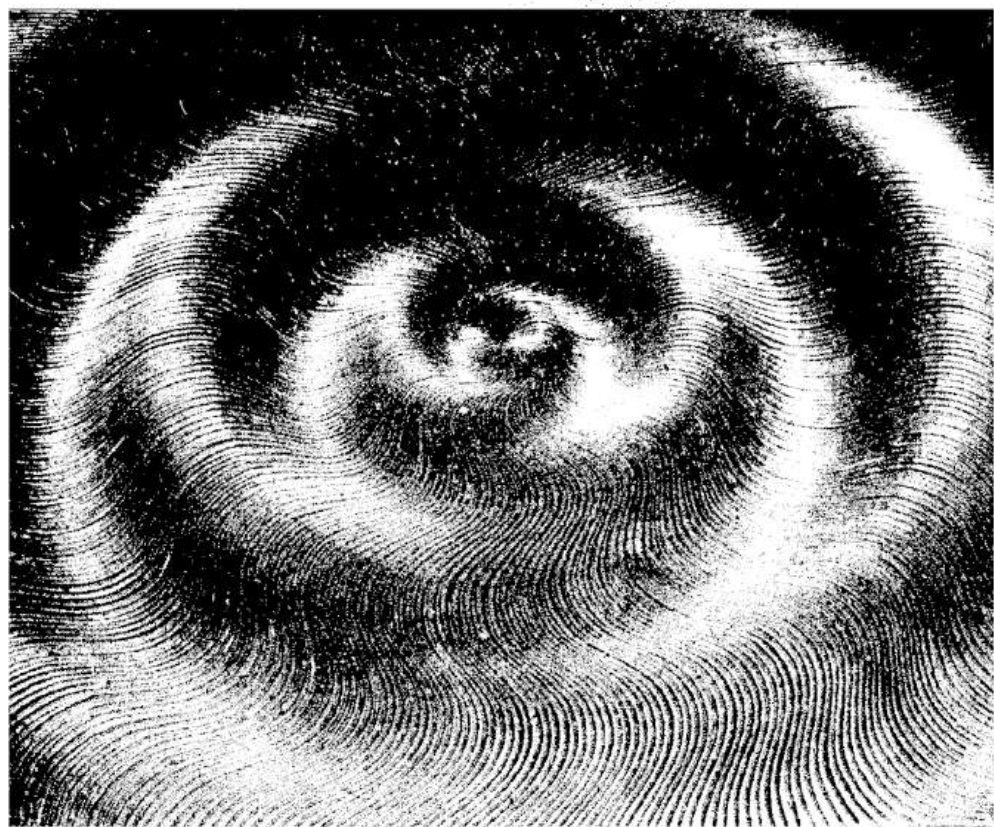


cosmic waves

from the dawn of time

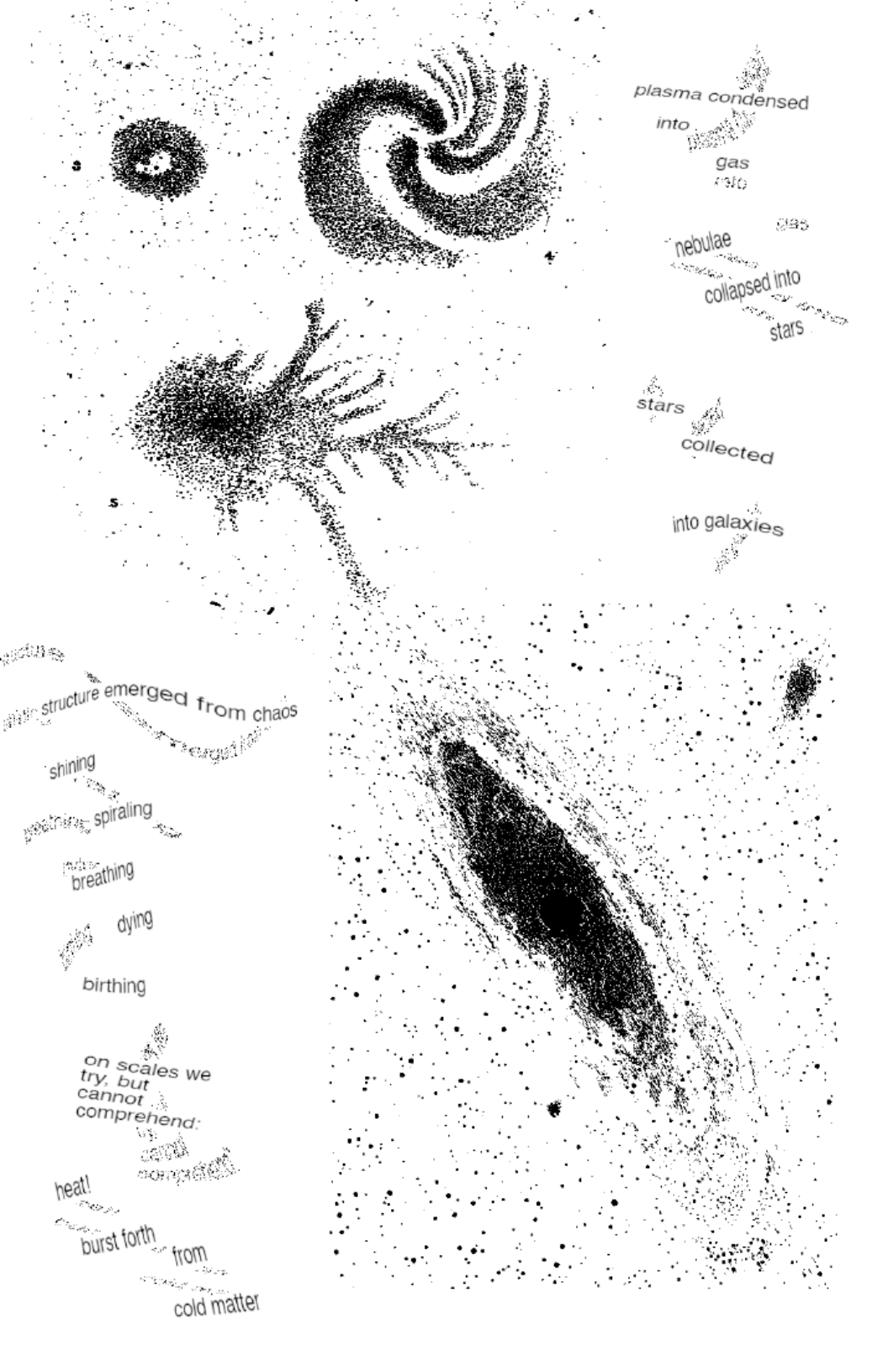
frozen in relative place

dancing in lock step



shape the structure

of our universe



plasma condensed
into
gas

gas
nebulae
collapsed into
stars

stars
collected

into galaxies

structure emerged from chaos
shining

breathing spiraling

breathing

dying

birthing

on scales we
try, but
cannot
comprehend:

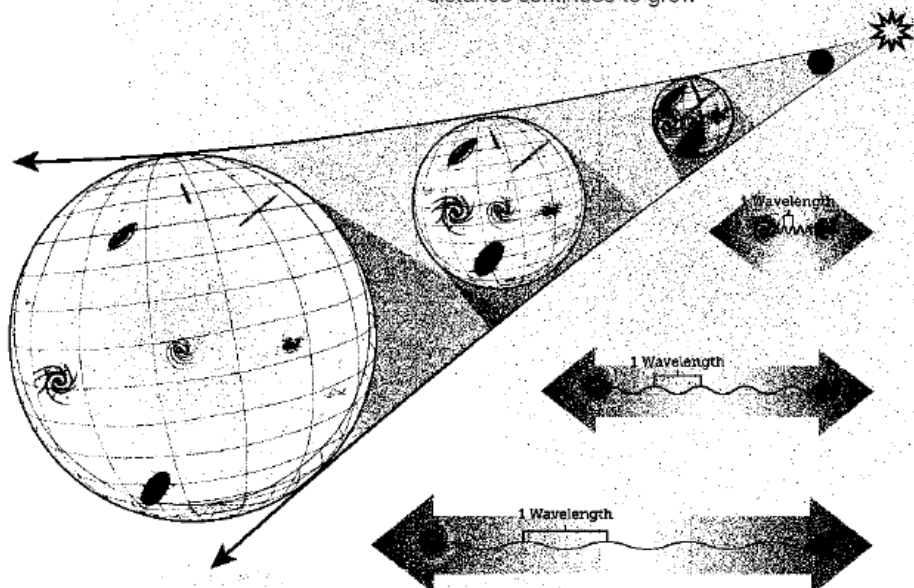
heat!

burst forth
from

cold matter

space continues to expand

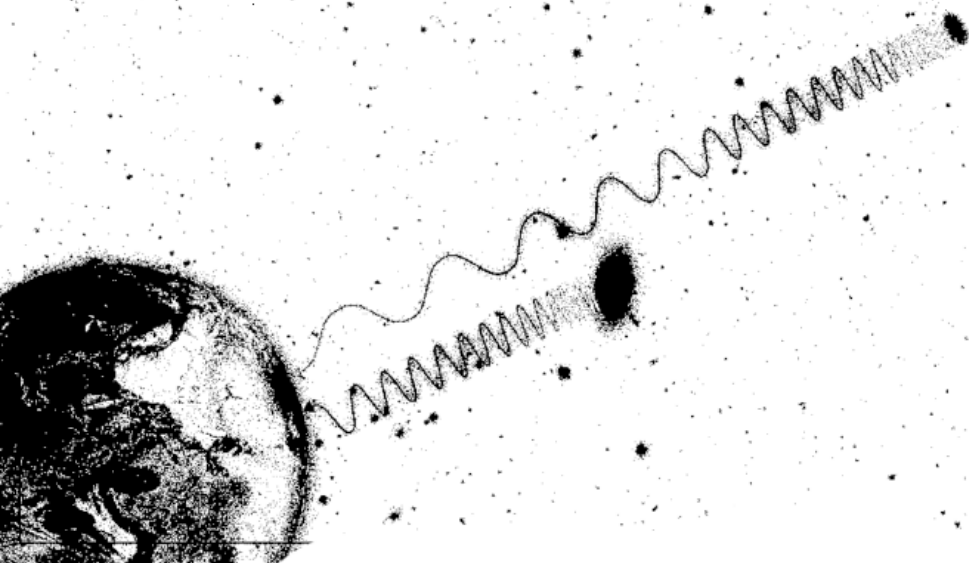
distance continues to grow



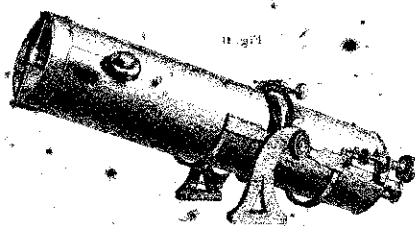
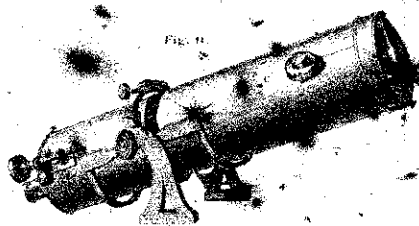
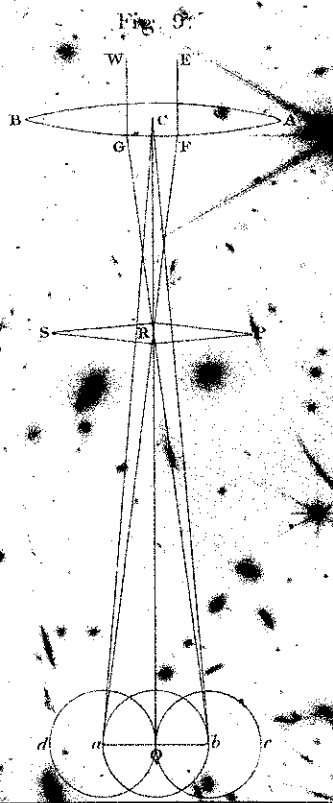
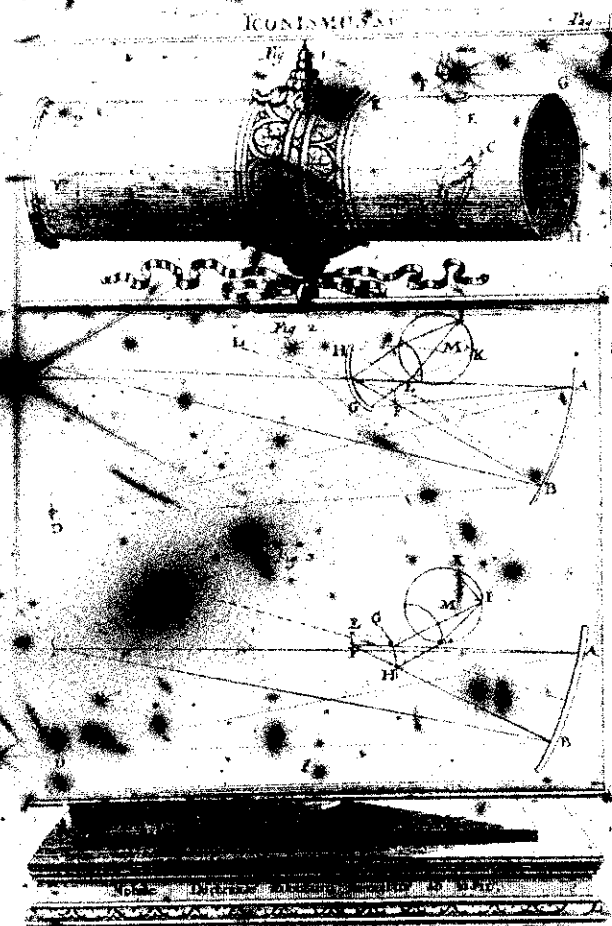
light becomes longer

redder

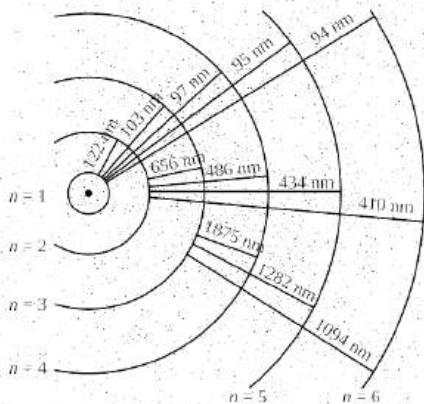
lower energy



we started counting galaxies



the structure of atoms
described by quantum mechanics
gives each element
a unique spectral signature

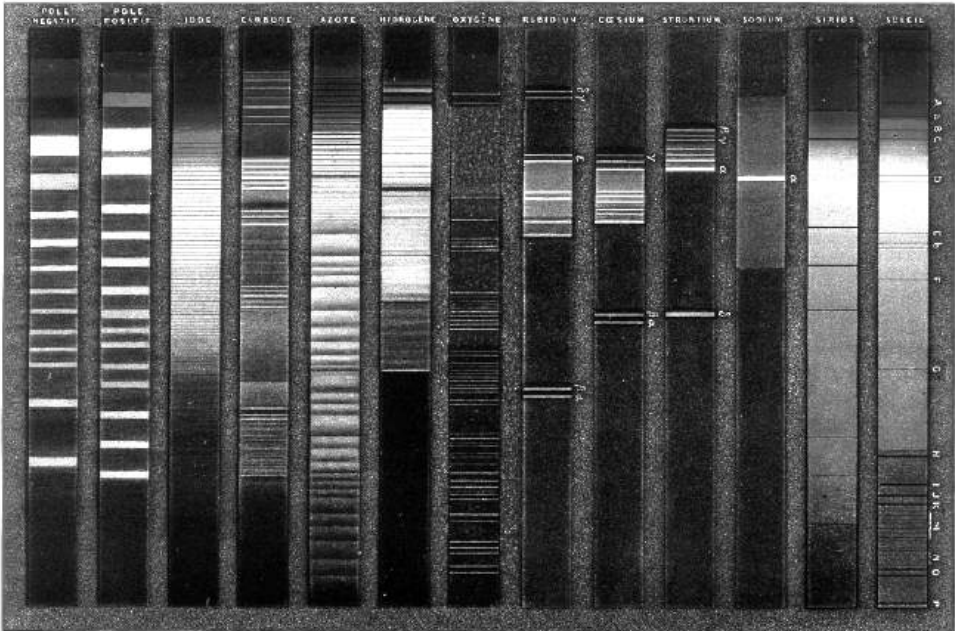


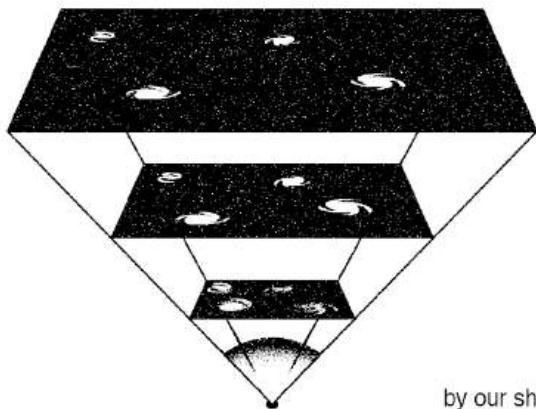
identities revealed when

starlight is

split

apart

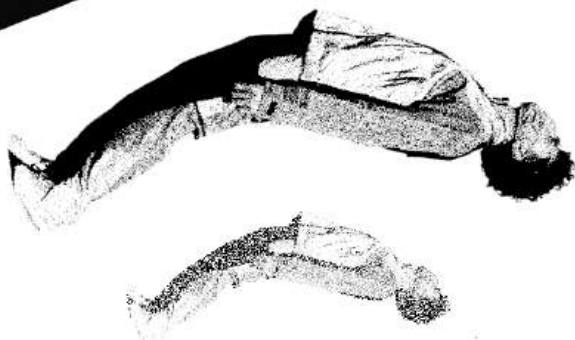
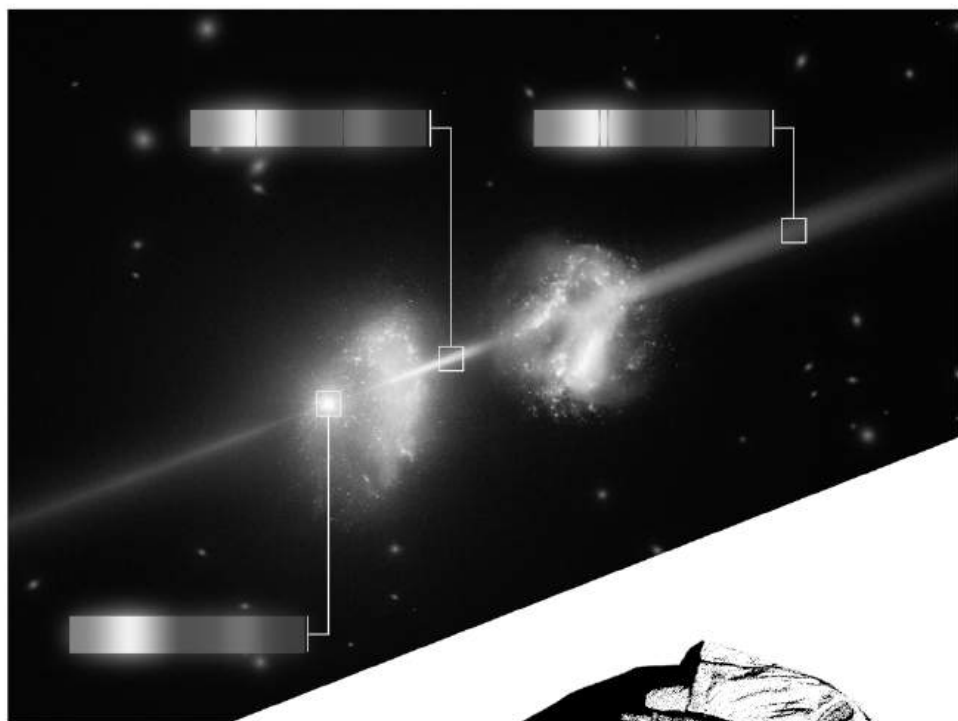


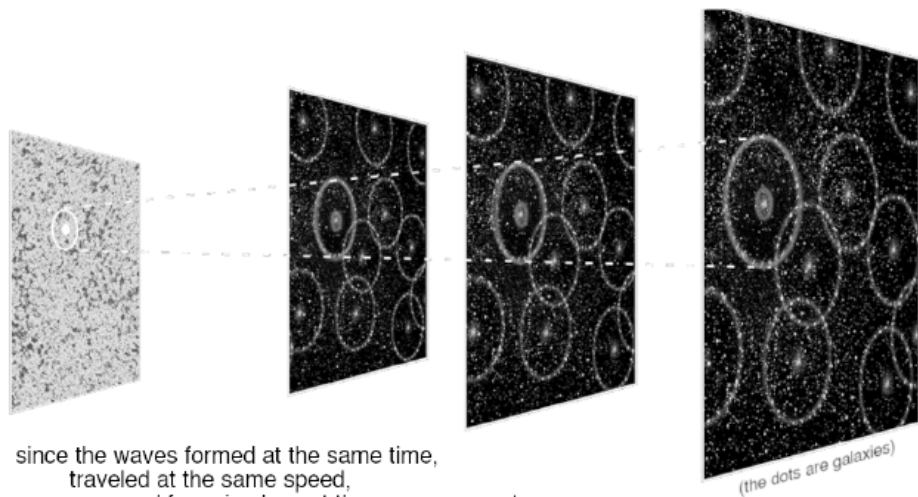


how far we've come

is told by

by our shifting spectra





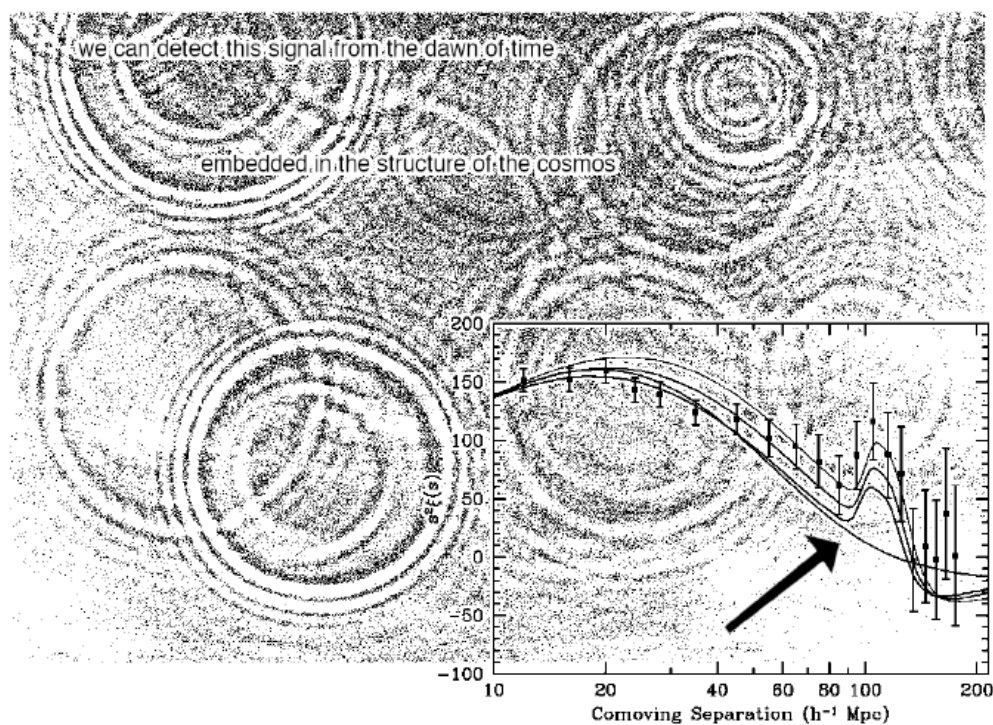
since the waves formed at the same time,
traveled at the same speed,
and froze in place at the same moment..

the rings they form are all the same size.

when a few more galaxies than expected

are found at this distance from each other

(with a bit of statistics)



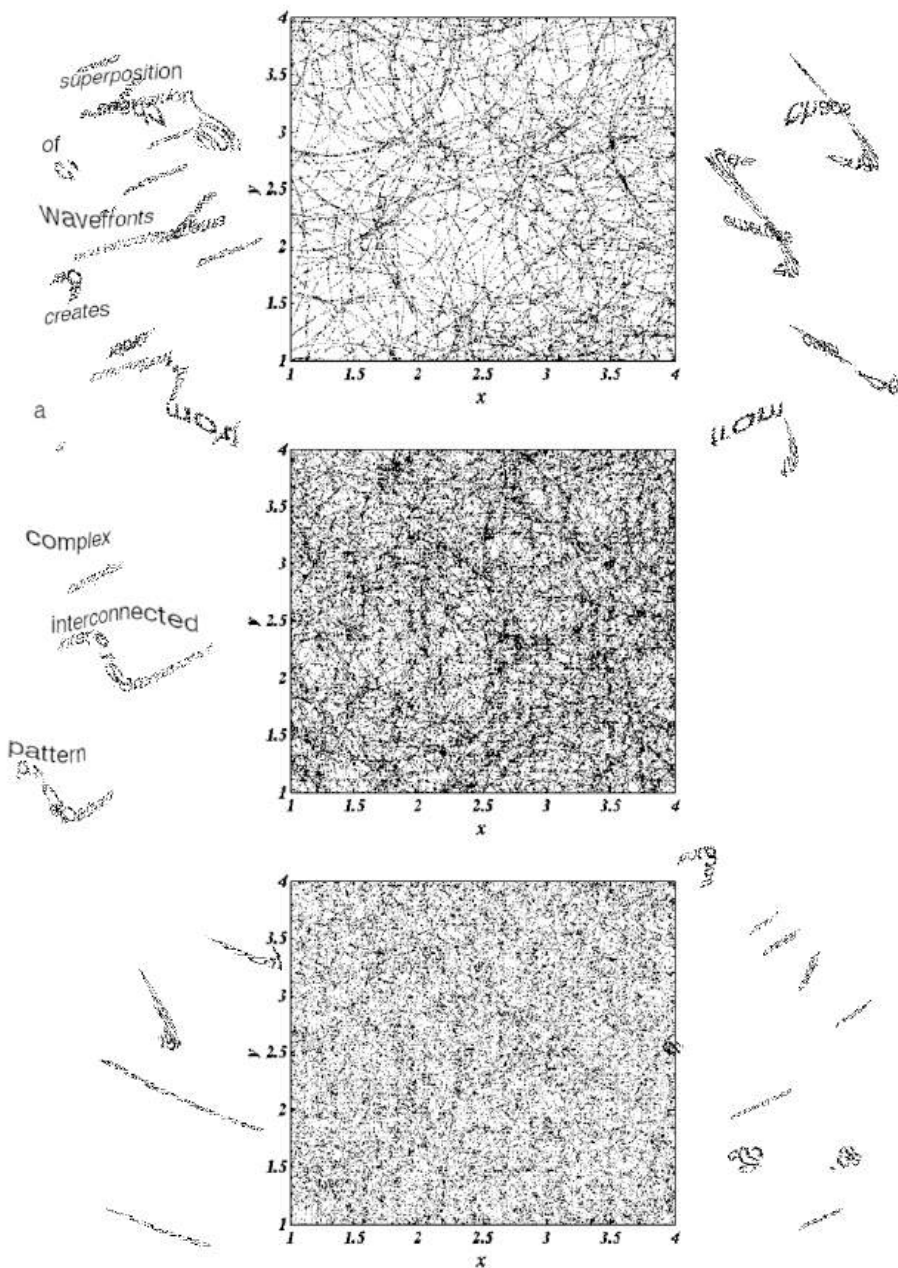
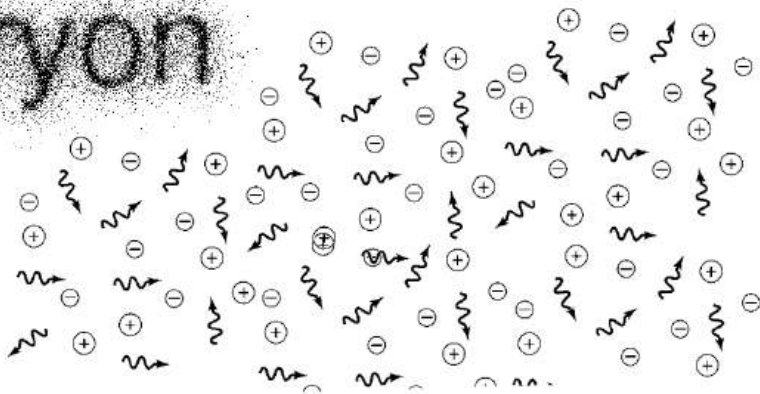


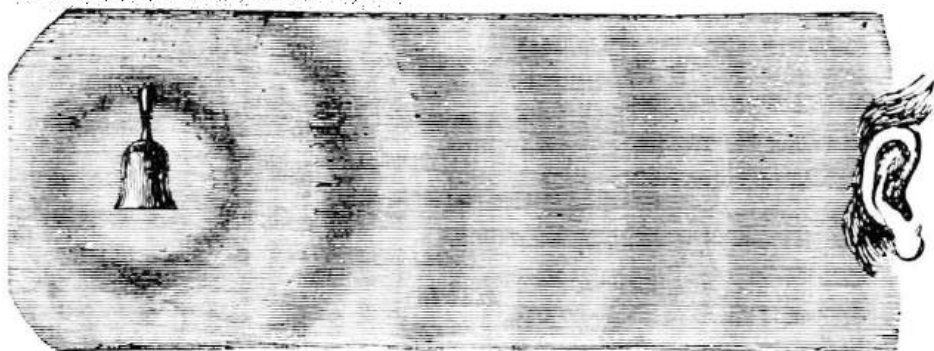
Fig. 1.17. Hiding the characteristic scale.

the underlying rings of power are lost, and must be recovered statistically.
The number of points are kept the same in each panel.

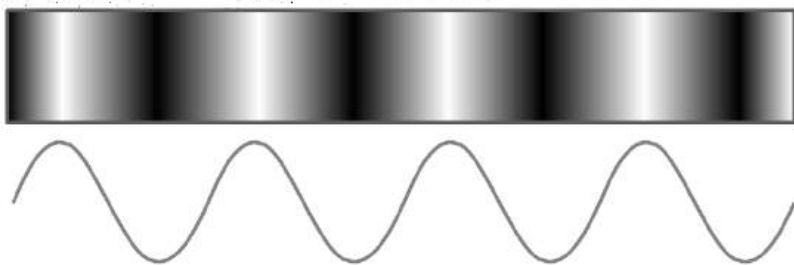
baryon



acoustic



oscillations



do you hear it?
we've seen the sound of creation
with our bleeding mechanical eyes

it tells me
it whispers
it shouts
in broken, chaotic bursts

I am the beginning, I am now

I am the law of the cosmos (order) manifest in the structure of the sky (your body)

I am your earliest memory your final breath I am now

I am cycles I am death I am clouds

I wait for you
to notice me

I have hidden myself in the sky

I am patient
but do you have time?
notice

like order
like structure

like water

like distance

like signal

like noise

from simplicity

emerges complexity

we are grown

we are known

we gather

and (re)turn to matter

and (re)turn to ether

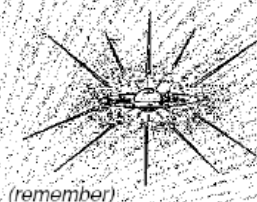
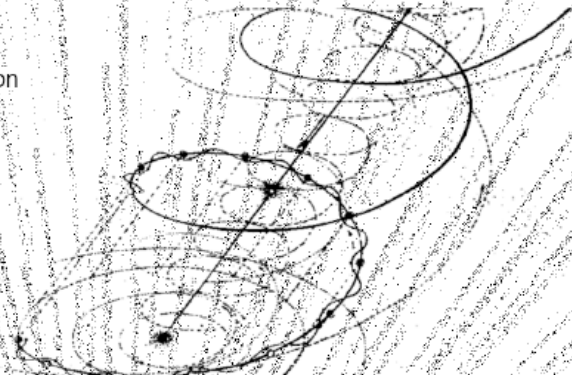
remember (reverberate)

the laws that govern me

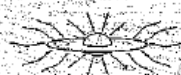
govern you, too

(remember)

(reverberate)



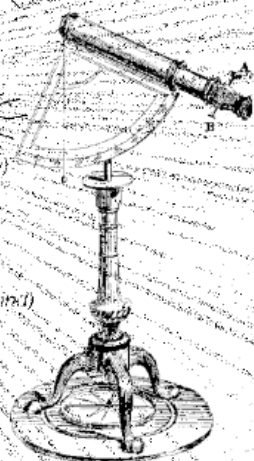
(remember)



(I have hidden myself in the sky)

(like chaos)

(like wind)



references

Discovering the Universe - Comins & Kaufmann, W. H. Freeman and Company, 2008
The Cosmic Symphony - Hu & White - *Scientific American*, Feb 2004
Detection of the Baryon Acoustic Peak in the Large-Scale Correlation Function of SDSS Luminous Red Galaxies - Eisenstein et al - *The Astrophysical Journal*, 633:560-574, Nov 2005
Baryon Acoustic Oscillations - Bassett & Hlozek - *Dark Energy: Observational and Theoretical Approaches*, Cambridge University Press, 2010

image attributions

James N. Inamura of University of Oregon: [6,8,12,22]
Discovering the Universe [6]
The Cosmic Symphony [7]
Pearson Education [7]
Big Think / Ben Gibson [11]
E. Siegel / Beyond the Galaxy [11]
NASA, ESA, Lisa Hustak (STScI) [16]
DES Collaboration [16]
James Argame [19]
ESA/Planck/Gabriela Secara/Perimeter Institute [20]
Eisenstein et al 2005 [20]
Bassett and Hlozek 2009 [21]
Shu et al 1987 [23]
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You, for reading my weird little zine about space:)

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TUCSON ARIZONA 2024