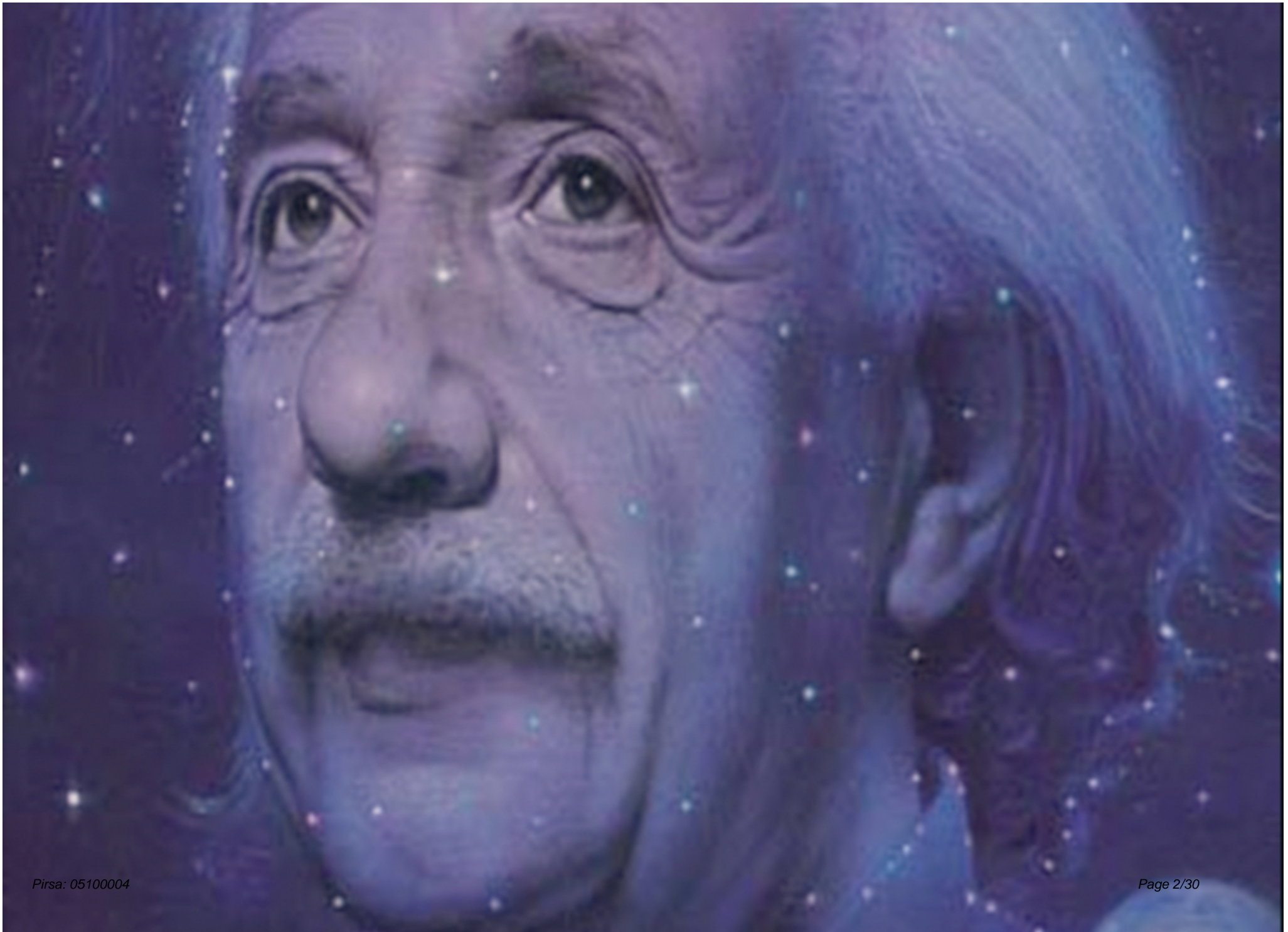


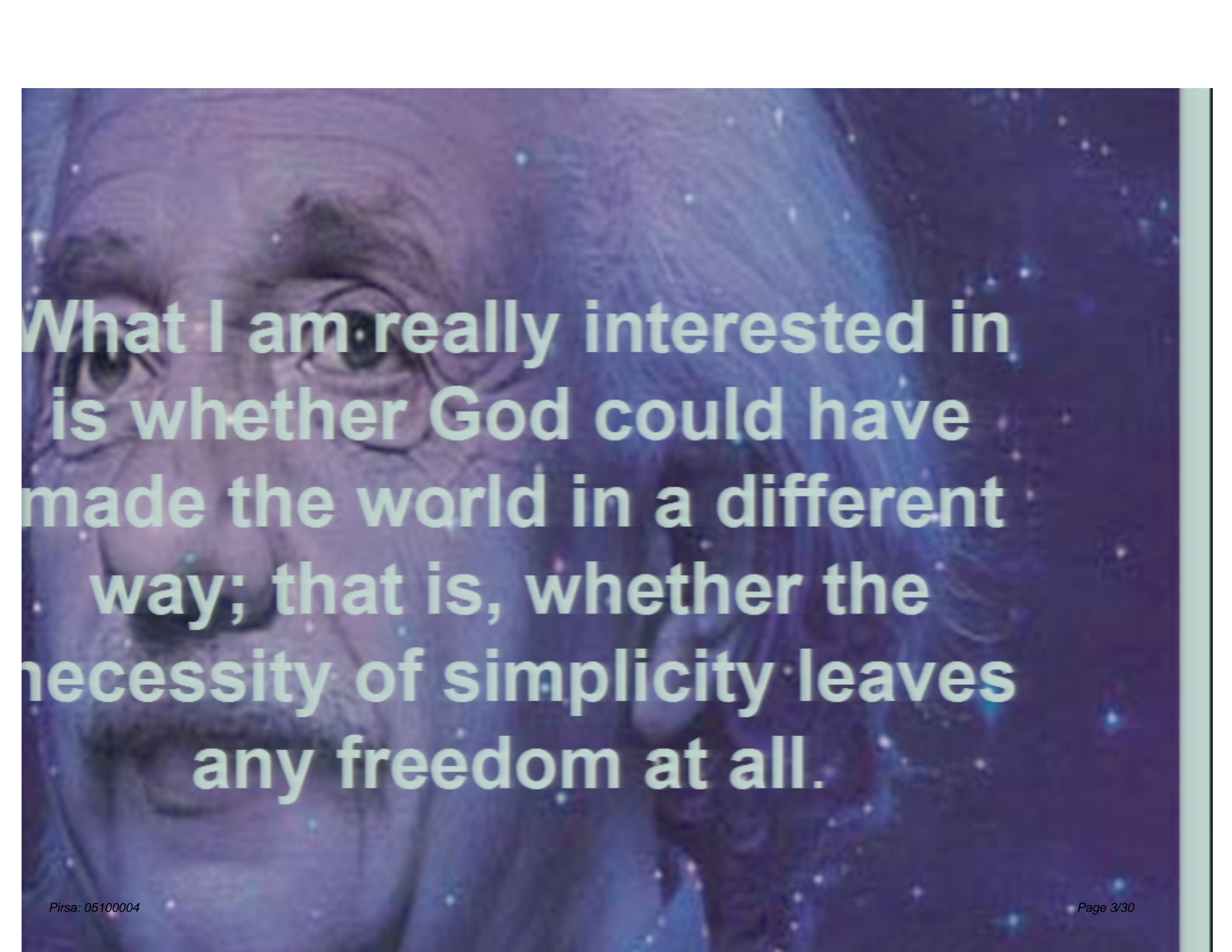
Title: April and May 1905: Witnessing Atoms

Date: Oct 02, 2005 10:00 AM

URL: <http://pirsa.org/05100004>

Abstract: In 1905, there were prominent scientists who did not believe in atoms. Einstein did. His April and May papers were motivated in part to support the concept of atoms. The April paper, Einstein's dissertation and one of his most cited papers, shows how the dimensions of a sugar molecule, suspended in water, can be determined. His method had many practical applications, hence the citations. In the May paper, a pollen particle took the place of a sugar molecule. For decades, the irregular, zig-zagging motion of pollen particles was a mystery. In a paper that is magic, Einstein showed how, with a simple ruler and a stopwatch, one could witness atoms at work and prove their existence. <kw> John S. Rigden, atoms, thermodynamics, kinetic theory, mechanism, coffee and cream, Brownian motion, </kw>





**What I am really interested in  
is whether God could have  
made the world in a different  
way; that is, whether the  
necessity of simplicity leaves  
any freedom at all.**



Light and Atoms



Thermodynamics and  
Kinetic Theory



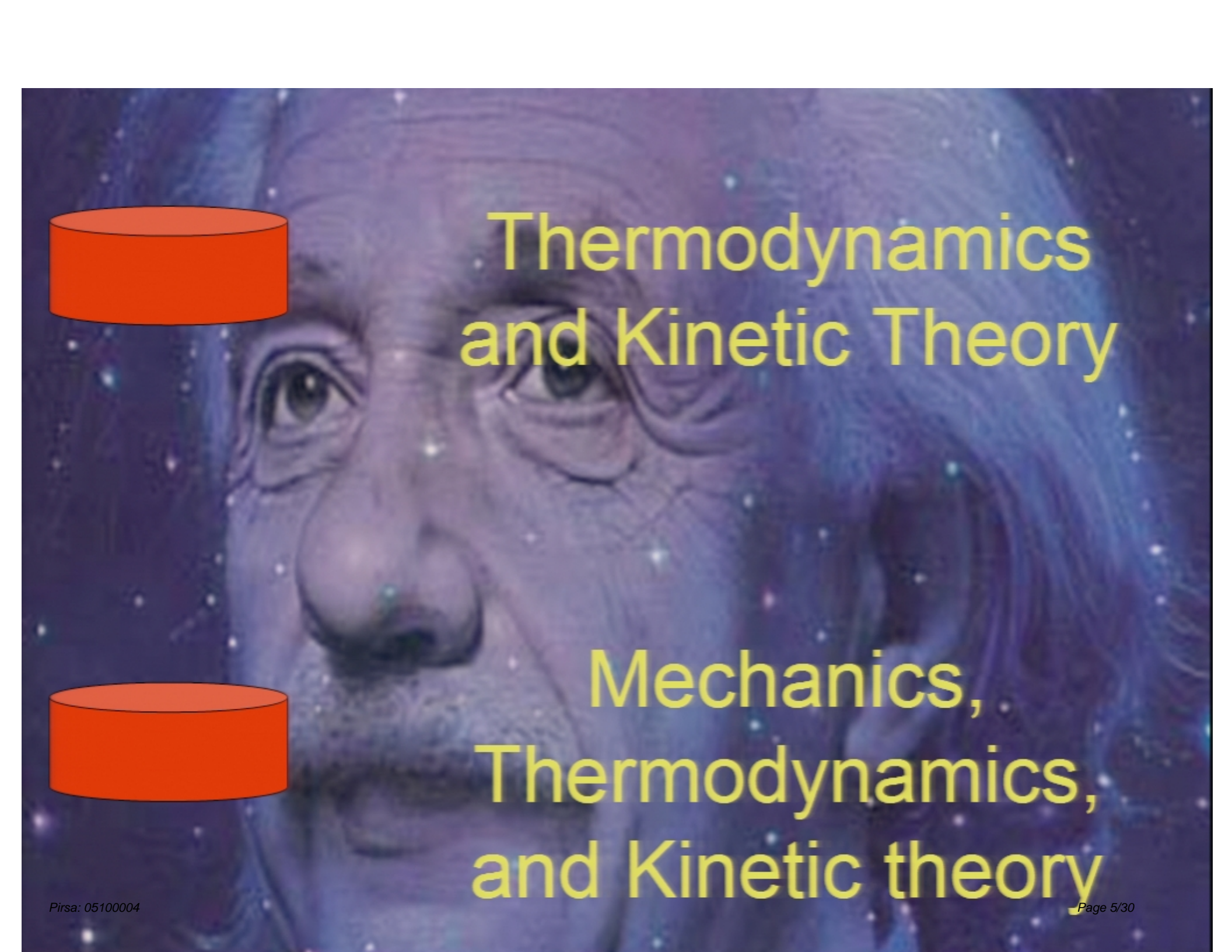
Mechanics, Thermo. and  
Kinetic Theory



Light and the Ether

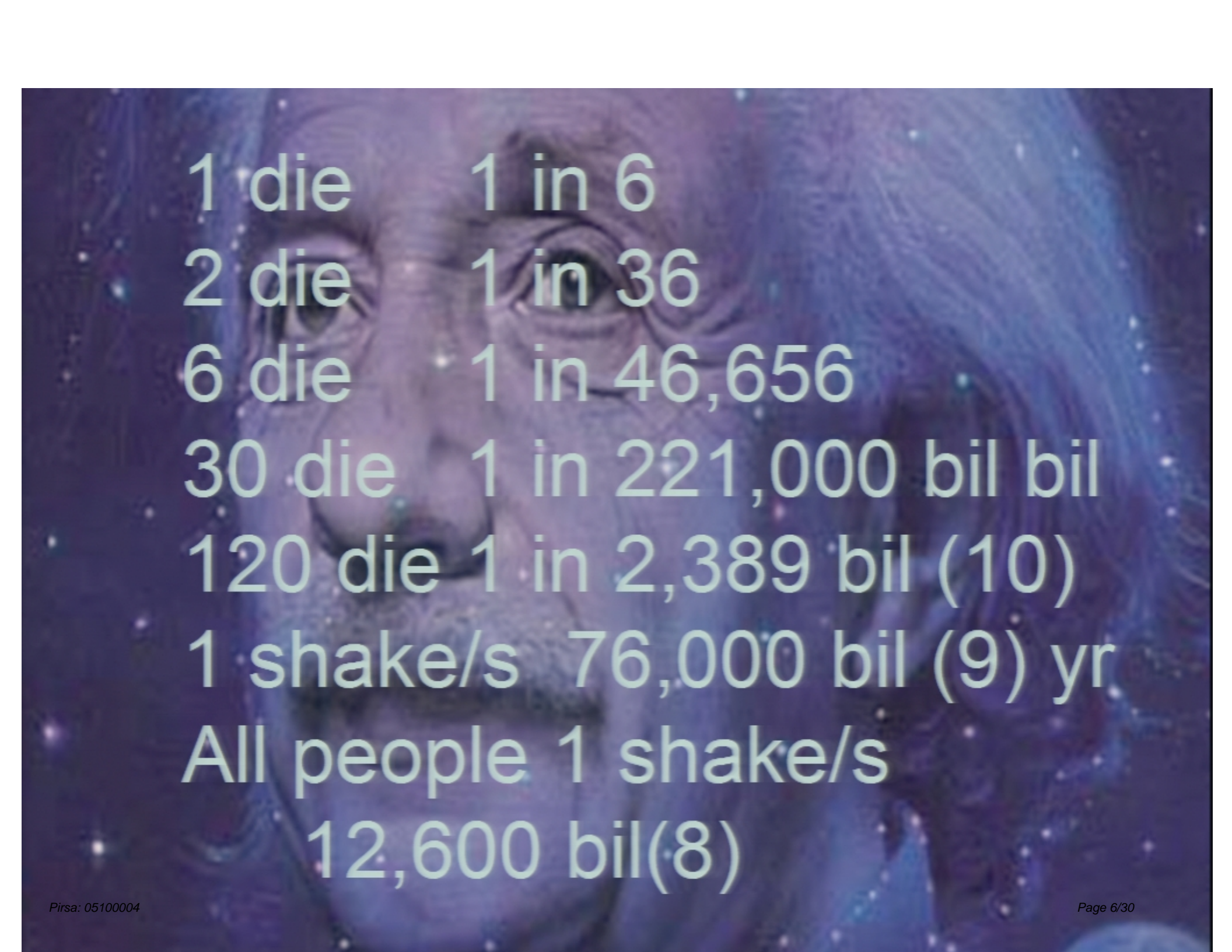


Mechanics and  
Electromagnetism


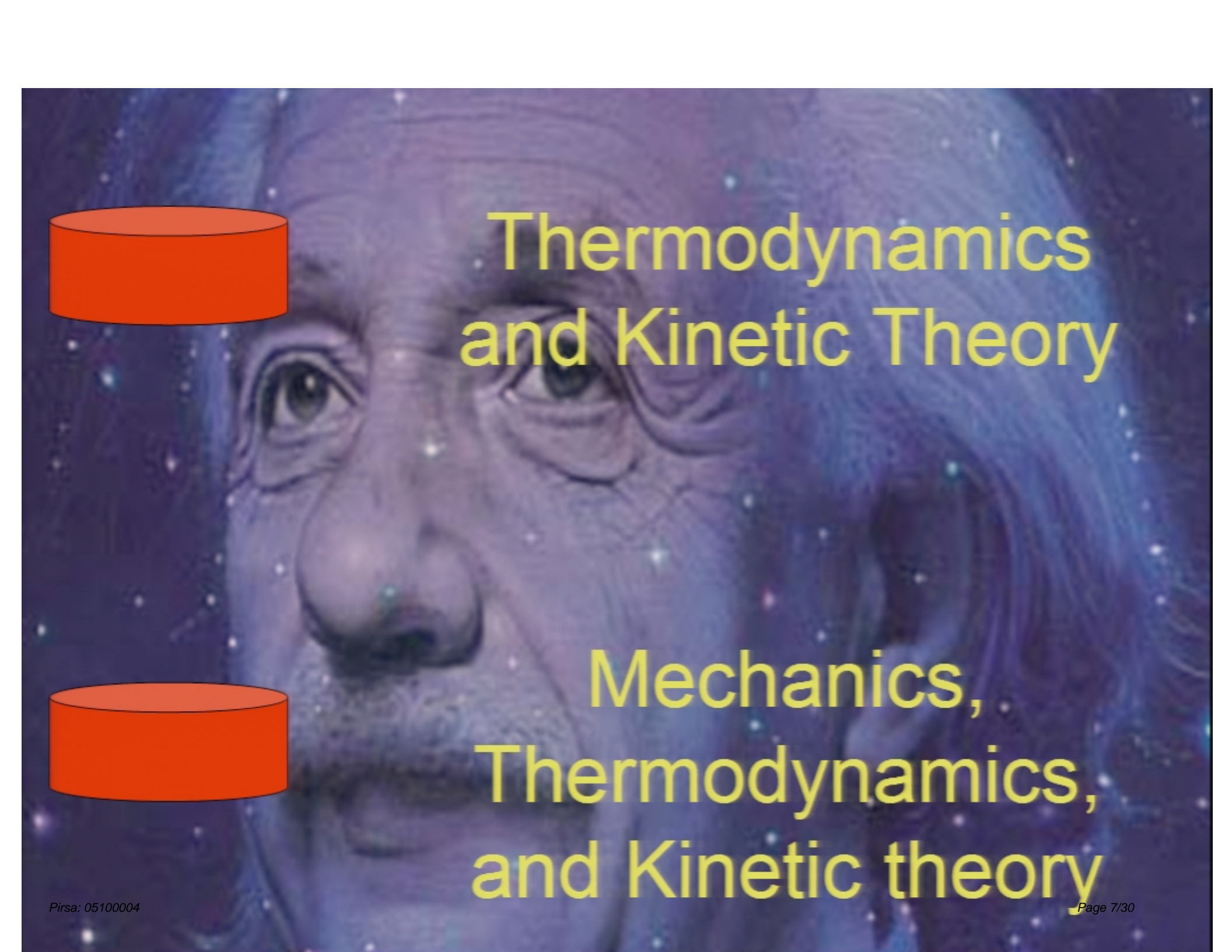


Thermodynamics  
and Kinetic Theory


Mechanics,  
Thermodynamics,  
and Kinetic theory



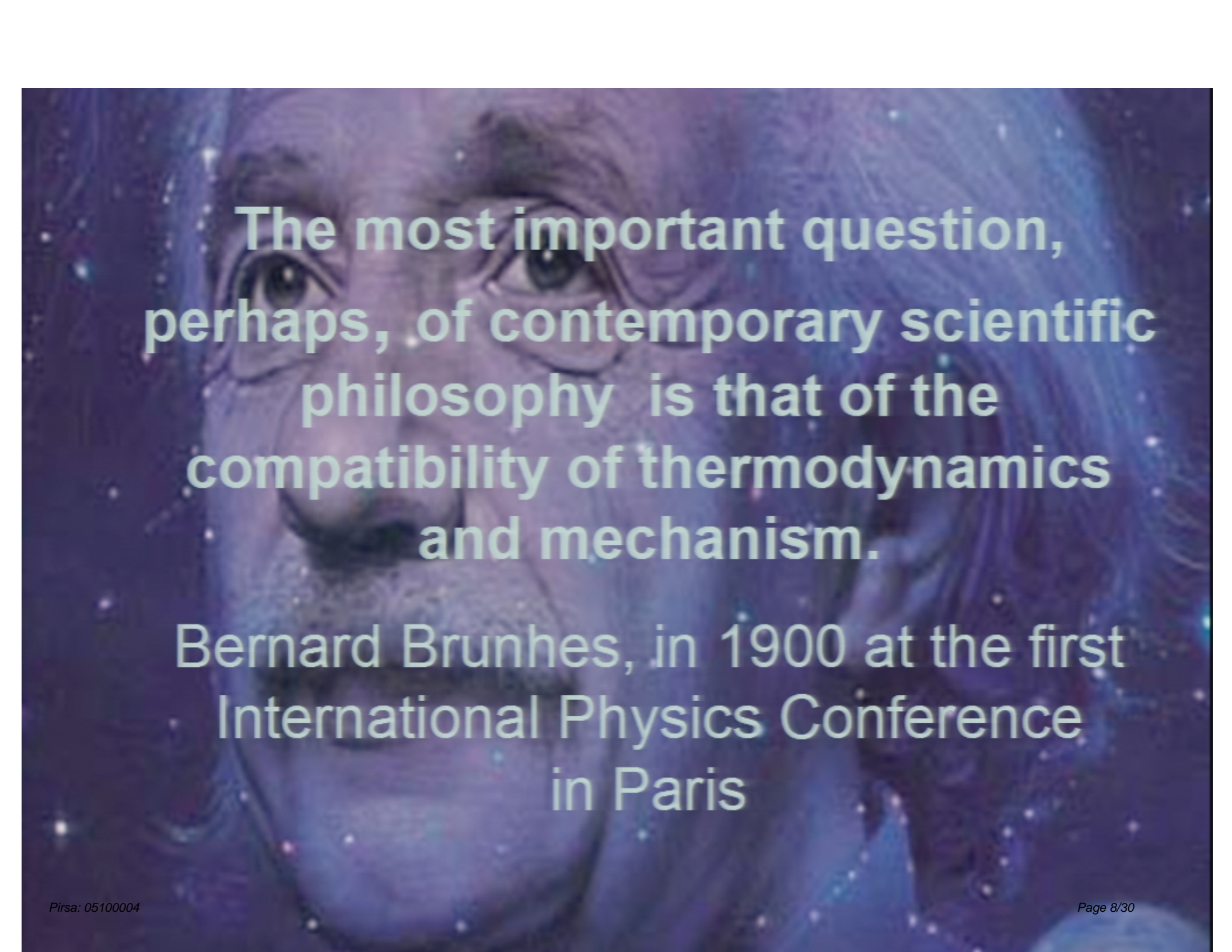
1 die 1 in 6  
2 die 1 in 36  
6 die 1 in 46,656  
30 die 1 in 221,000 bil bil  
120 die 1 in 2,389 bil (10)  
1 shake/s 76,000 bil (9) yr  
All people 1 shake/s  
12,600 bil(8)



# Thermodynamics and Kinetic Theory



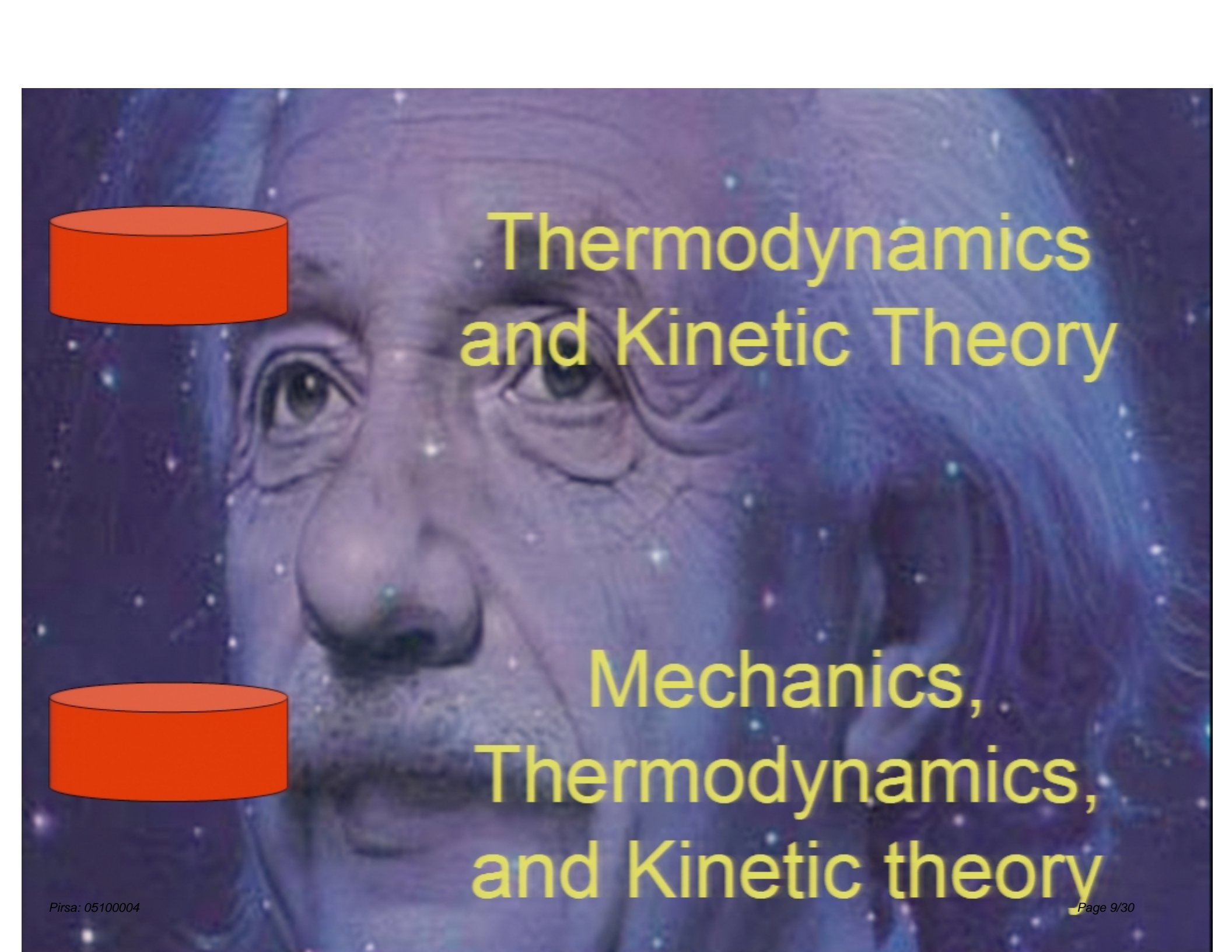
## Mechanics, Thermodynamics, and Kinetic theory

A blue-tinted portrait of Bernard Brunhes, an elderly man with a mustache and glasses, looking slightly to the right. The background is a dark blue space with many small white stars. The text is overlaid on the image in a white, sans-serif font.

**The most important question,  
perhaps, of contemporary scientific  
philosophy is that of the  
compatibility of thermodynamics  
and mechanism.**

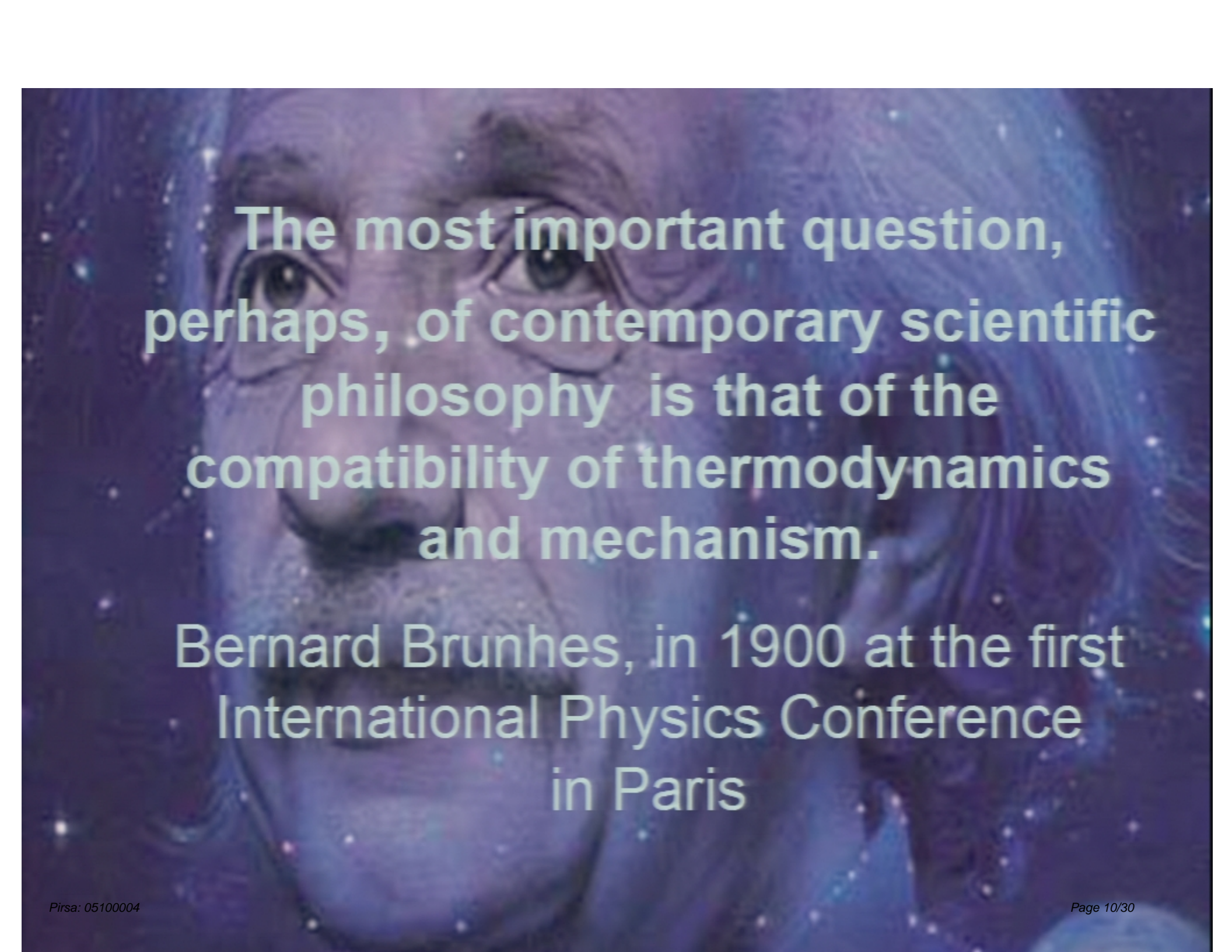
Bernard Brunhes, in 1900 at the first  
International Physics Conference  
in Paris






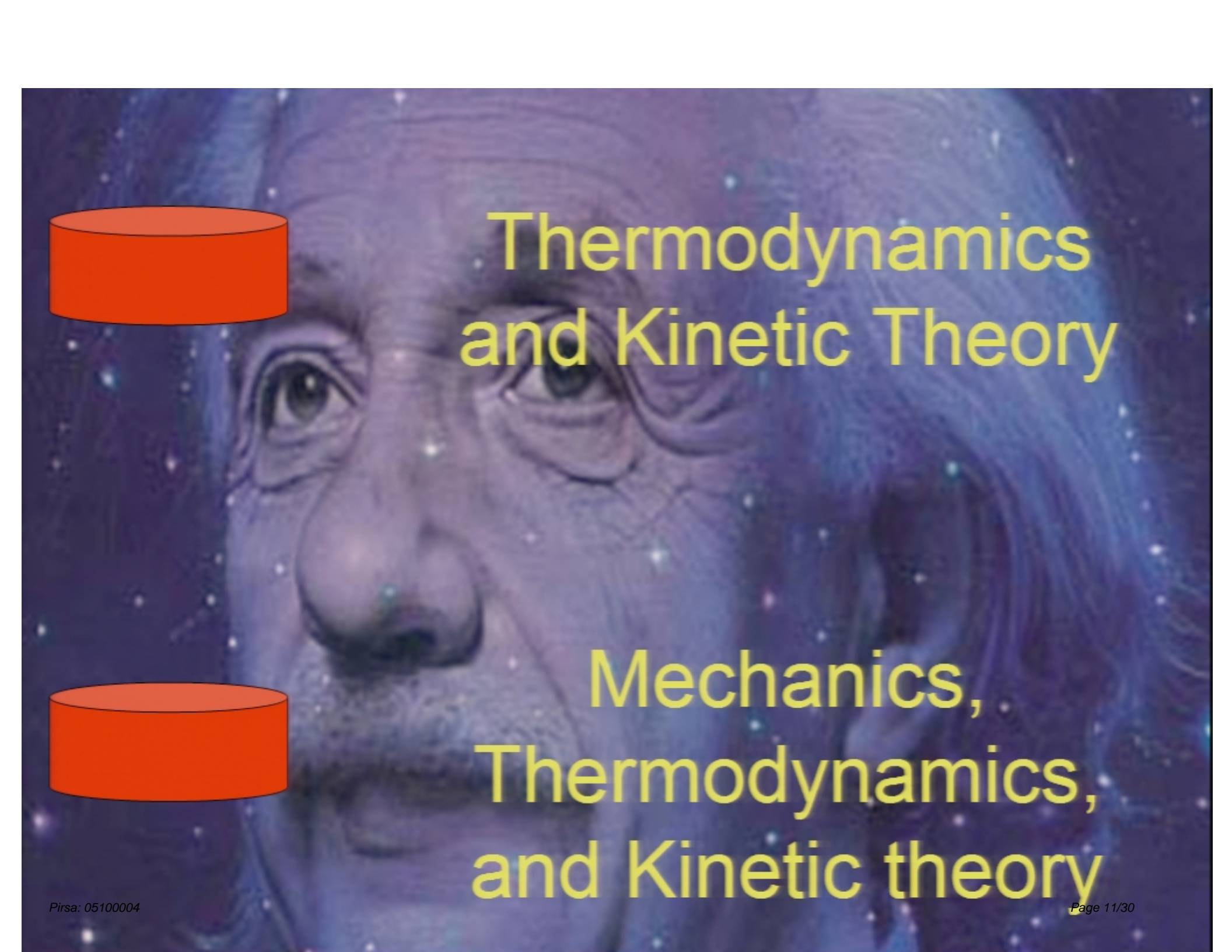
Thermodynamics  
and Kinetic Theory

Mechanics,  
Thermodynamics,  
and Kinetic theory


A portrait of Bernard Brunhes, an elderly man with a full white beard and mustache, wearing a dark suit and a white shirt with a dark tie. He is looking slightly to the right of the camera with a thoughtful expression. The background is a dark, textured blue with some light spots, possibly representing a starry sky or a similar abstract pattern.

**The most important question,  
perhaps, of contemporary scientific  
philosophy is that of the  
compatibility of thermodynamics  
and mechanism.**

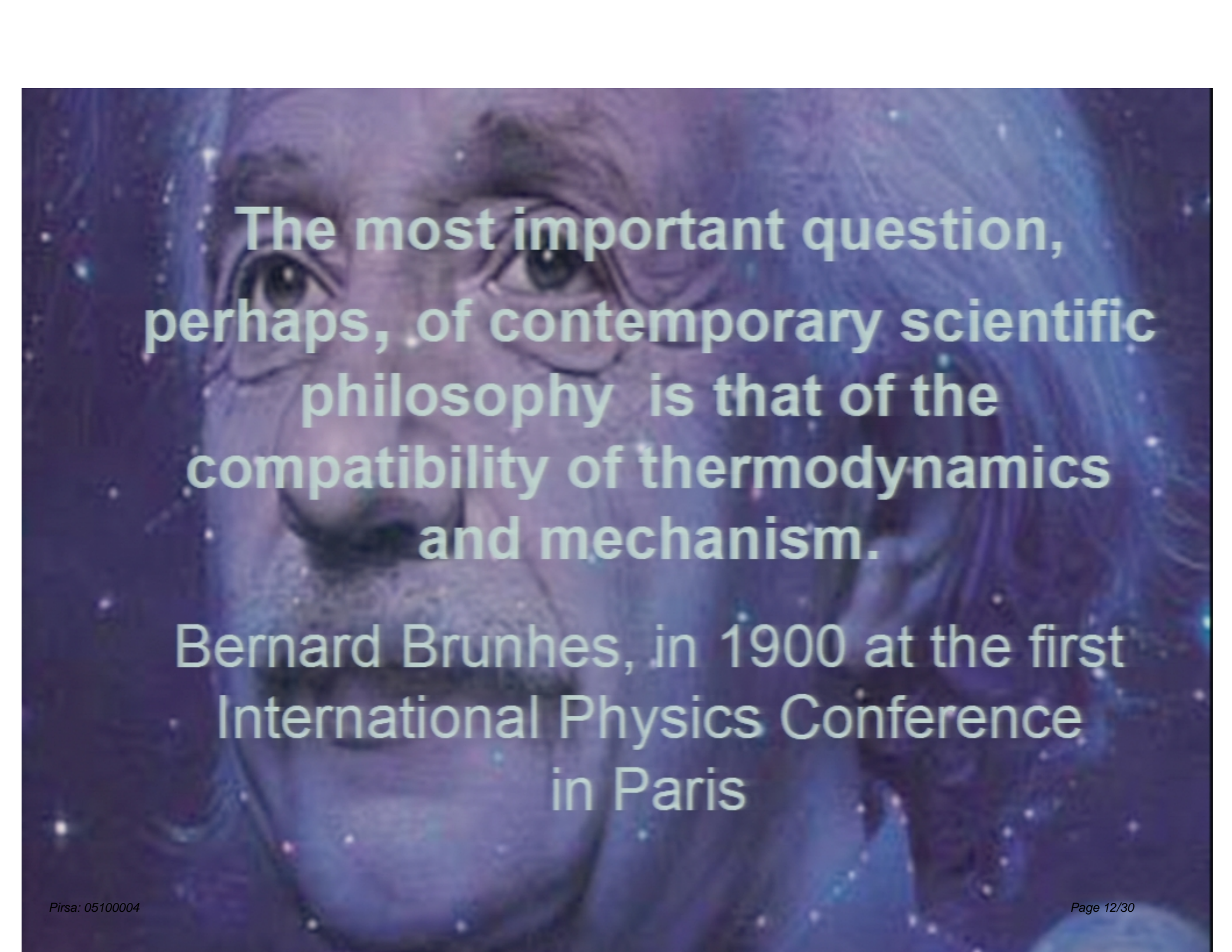
Bernard Brunhes, in 1900 at the first  
International Physics Conference  
in Paris



# Thermodynamics and Kinetic Theory



Mechanics,  
Thermodynamics,  
and Kinetic theory

A close-up portrait of Bernard Brunhes, an elderly man with a full white beard and mustache, wearing round glasses. He is looking slightly to the right of the camera with a thoughtful expression. The background is a dark, starry space with a blue and purple color palette.

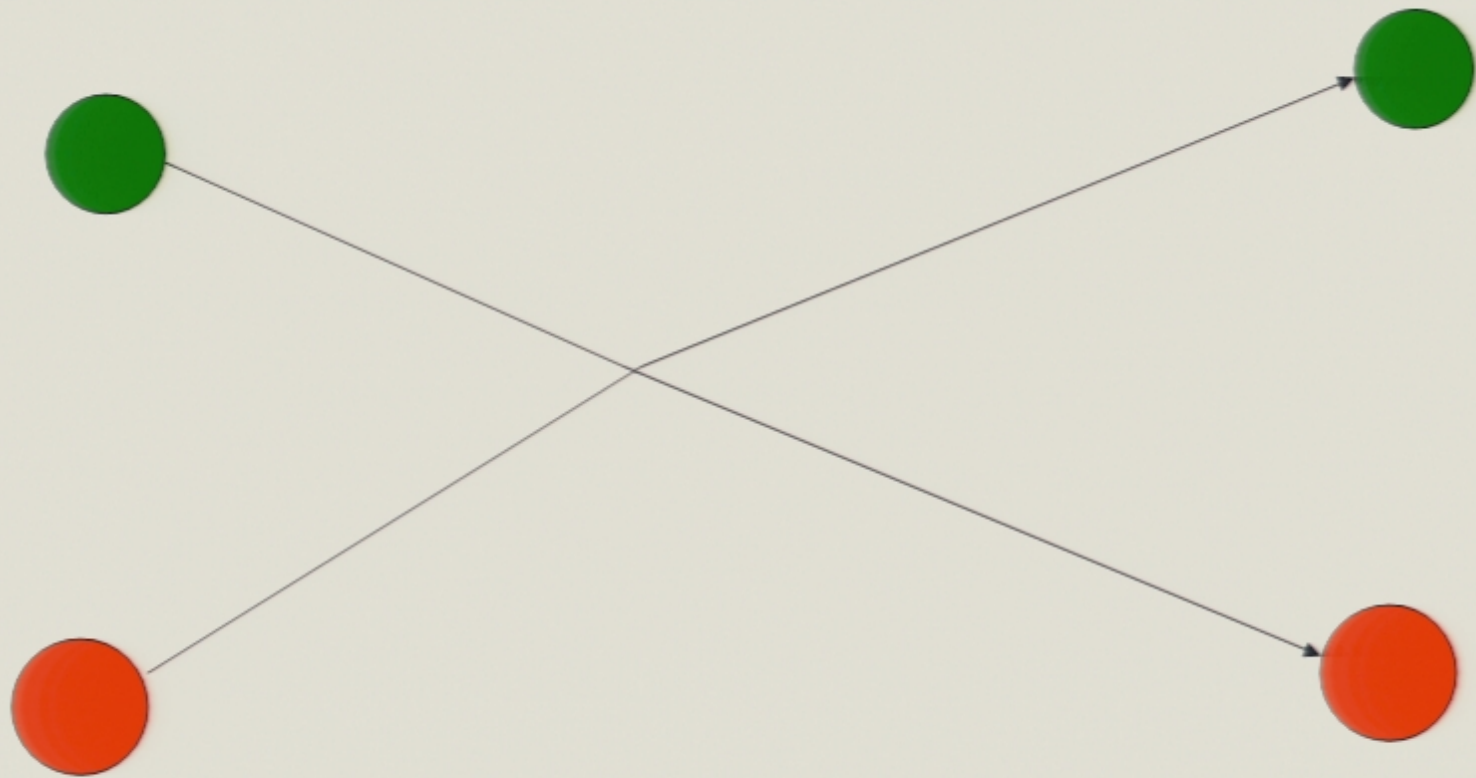
**The most important question,  
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compatibility of thermodynamics  
and mechanism.**

Bernard Brunhes, in 1900 at the first  
International Physics Conference  
in Paris

COFFEE



CREAM

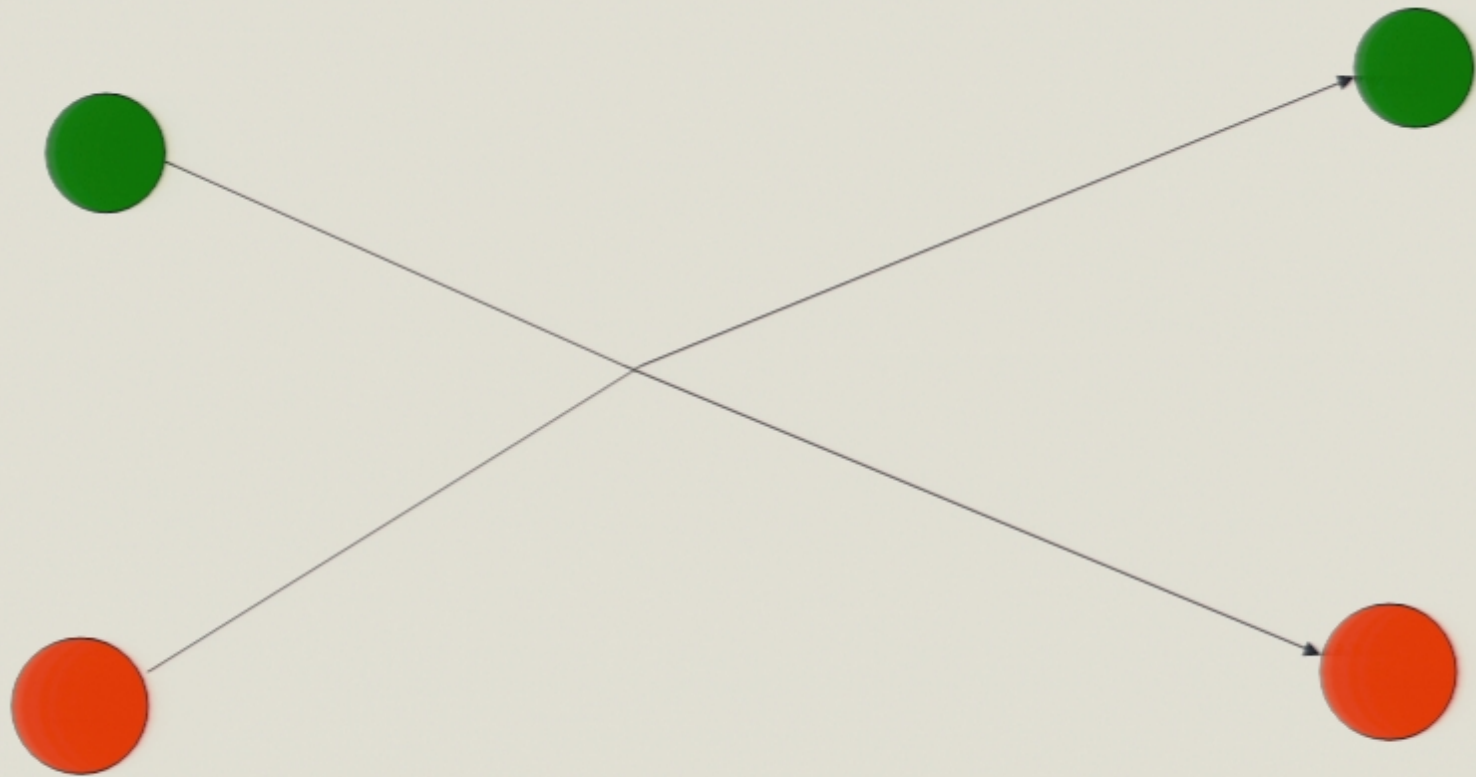


COLLISION

COFFEE



CREAM



COLLISION



COFFEE



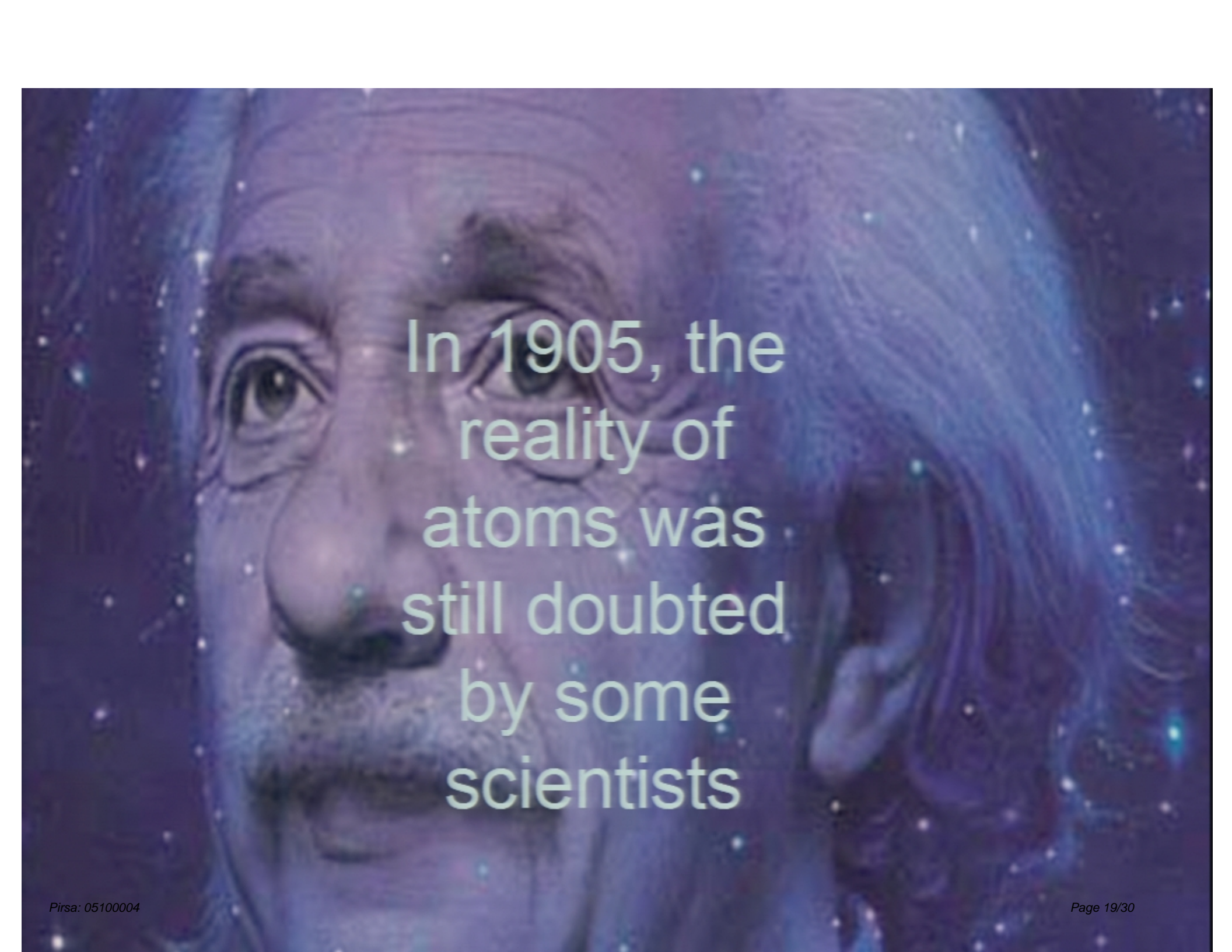
CREAM



1905 Papers #2 and #3  
April 30, and May 10, 1905

Dimensions of atoms  
(Einstein's dissertation)

Brownian Motion  
(Proof of atom's existence)

A blue-tinted portrait of Albert Einstein, looking slightly to the left. The background is a dark blue space filled with numerous small, bright white stars. The text is overlaid in the center of the image.

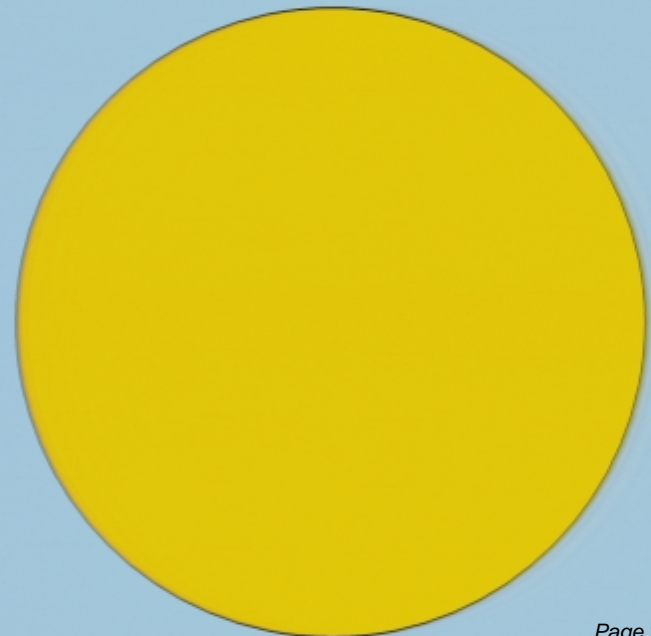
In 1905, the  
reality of  
atoms was  
still doubted  
by some  
scientists

April

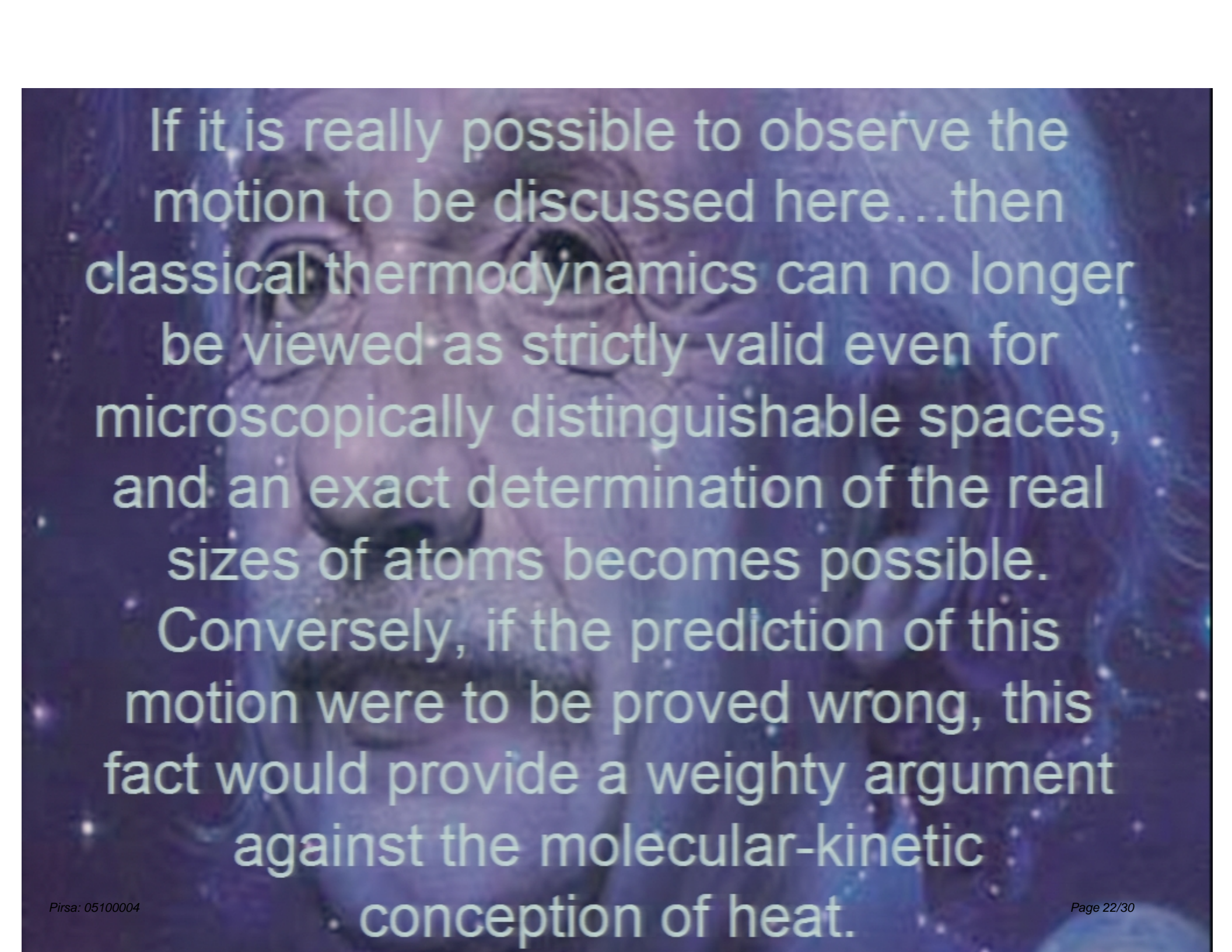
Sugar  
molecule in  
water

May

Pollen  
particle in  
water



It will be shown in this paper that the size of molecules of substances dissolved in...solution can be obtained...if the volume [size] of the molecule of the dissolved substance is large compared with the volume [size] of the molecule of the solvent....This is because...such **a molecule will behave approximately as a solid body suspended in a solvent....**

A portrait of Albert Einstein is centered in the background, overlaid on a dark blue space-themed background with white stars and nebulae. The text is overlaid on this image in a light blue, sans-serif font.

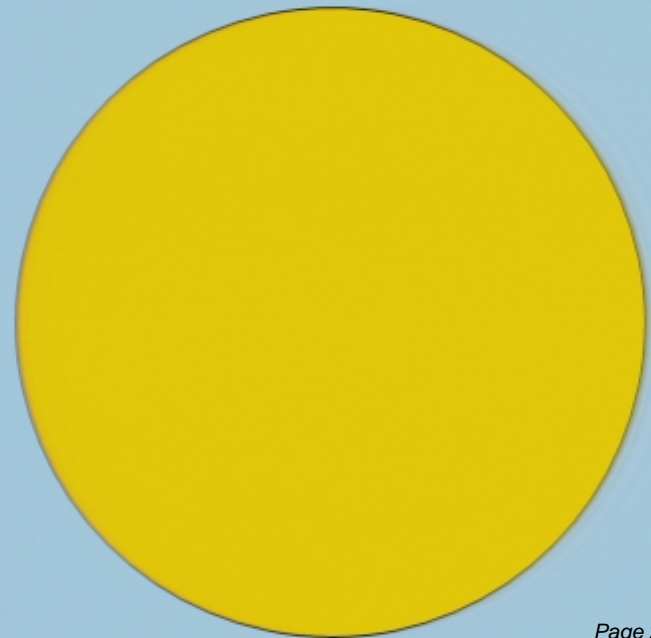
If it is really possible to observe the motion to be discussed here...then classical thermodynamics can no longer be viewed as strictly valid even for microscopically distinguishable spaces, and an exact determination of the real sizes of atoms becomes possible. Conversely, if the prediction of this motion were to be proved wrong, this fact would provide a weighty argument against the molecular-kinetic conception of heat.

April

Sugar  
molecule in  
water

May

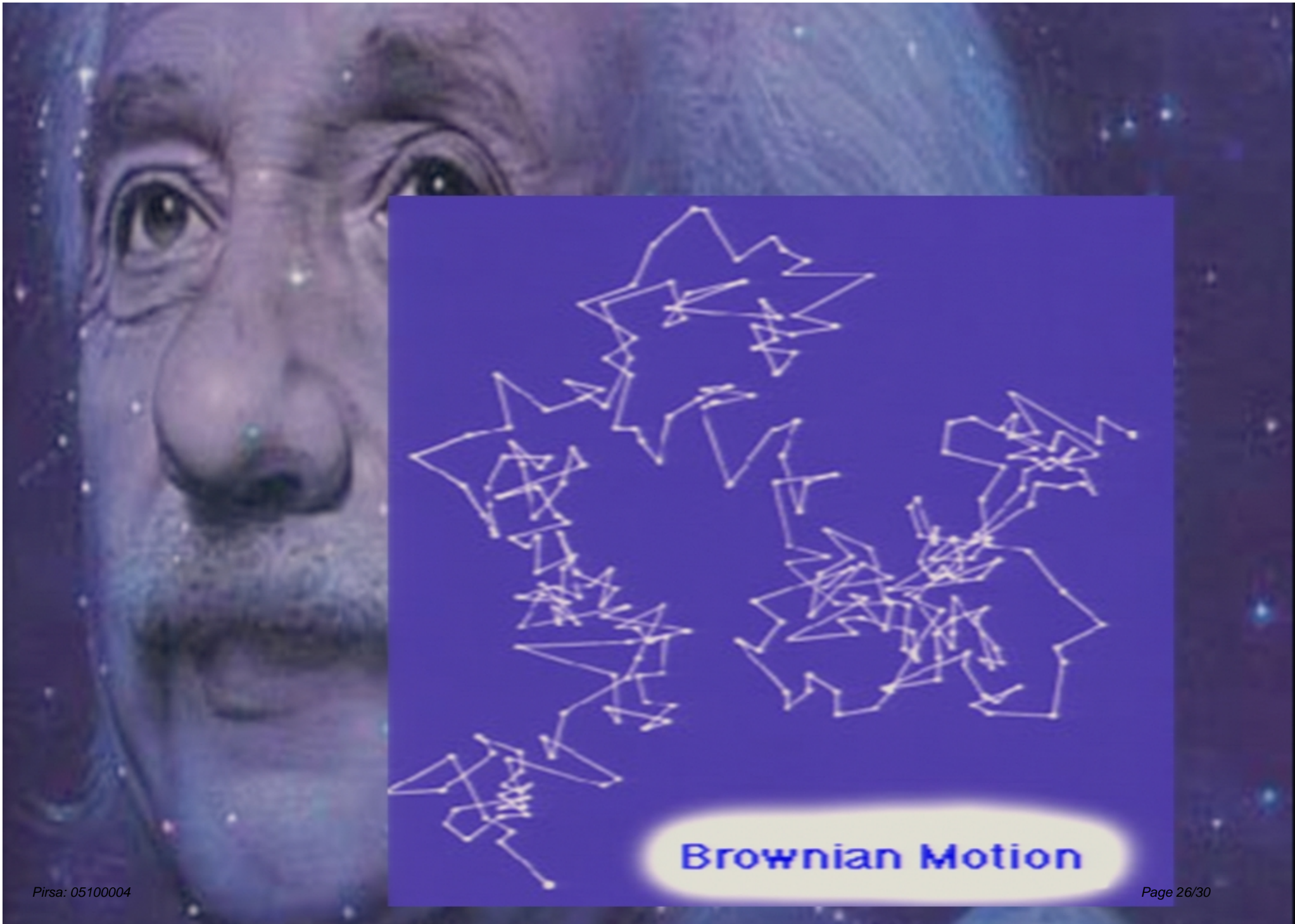
Pollen  
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It will be shown in this paper that the size of molecules of substances dissolved in...solution can be obtained...if the volume [size] of the molecule of the dissolved substance is large compared with the volume [size] of the molecule of the solvent....This is because...such **a molecule will behave approximately as a solid body suspended in a solvent....**

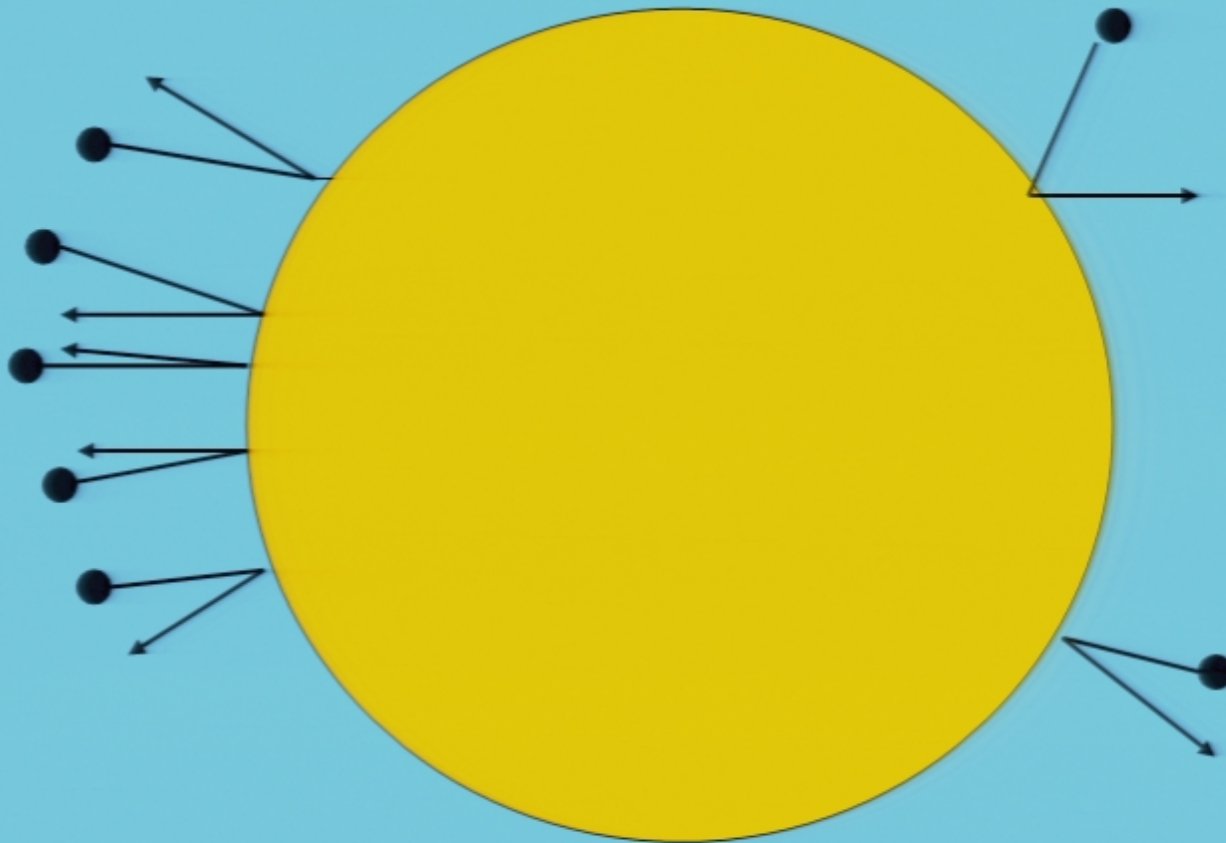


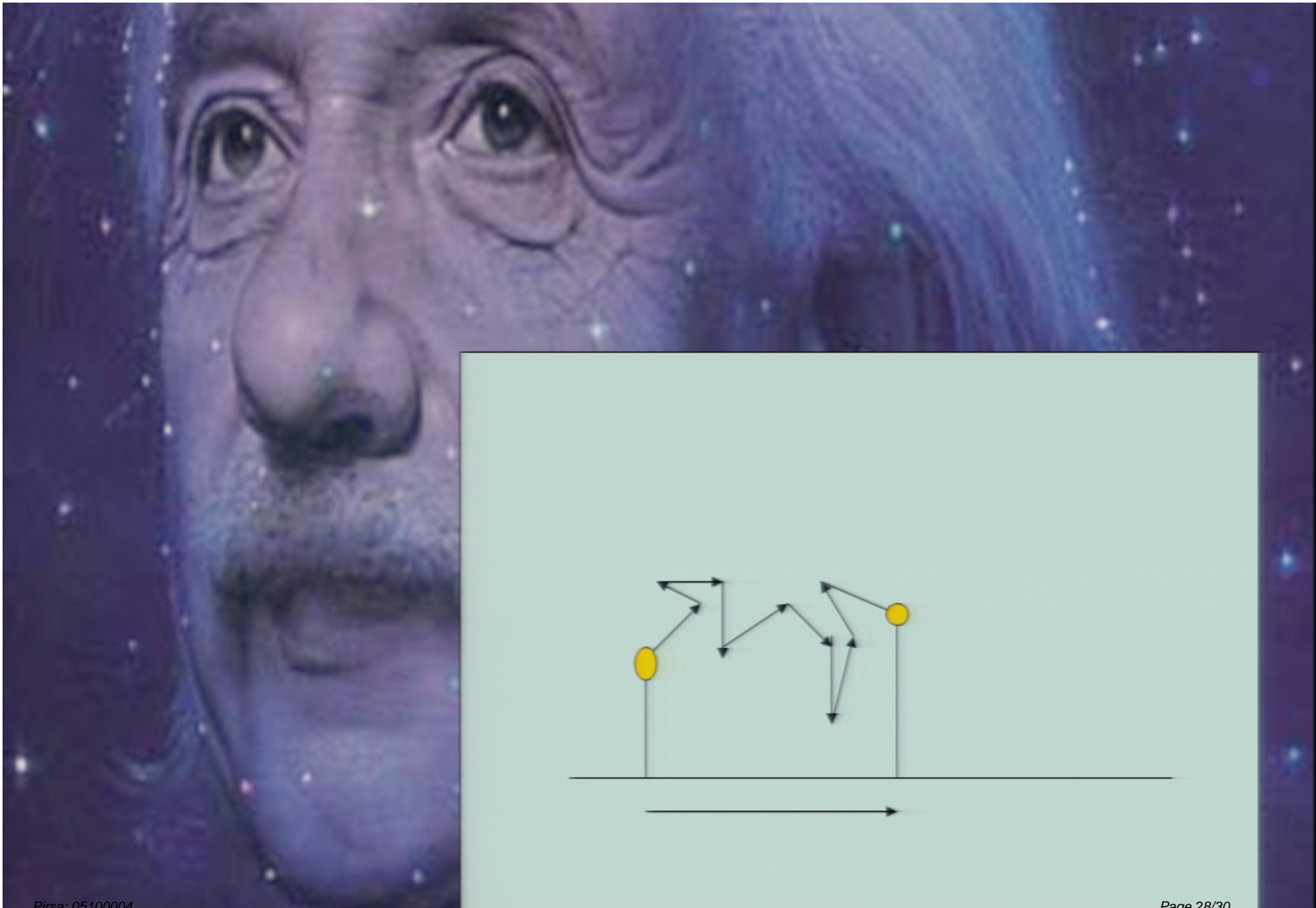
...a dissolved molecule differs from a suspended body in size *alone*, and it is difficult to see why suspended bodies should not produce the same osmotic pressure as an equal number of dissolved molecules. We will have to assume that the suspended bodies perform an irregular, even though very slow, motion in the liquid due to the liquid's molecular motion....



**Brownian Motion**

Water molecules colliding with  
pollen a pollen particle

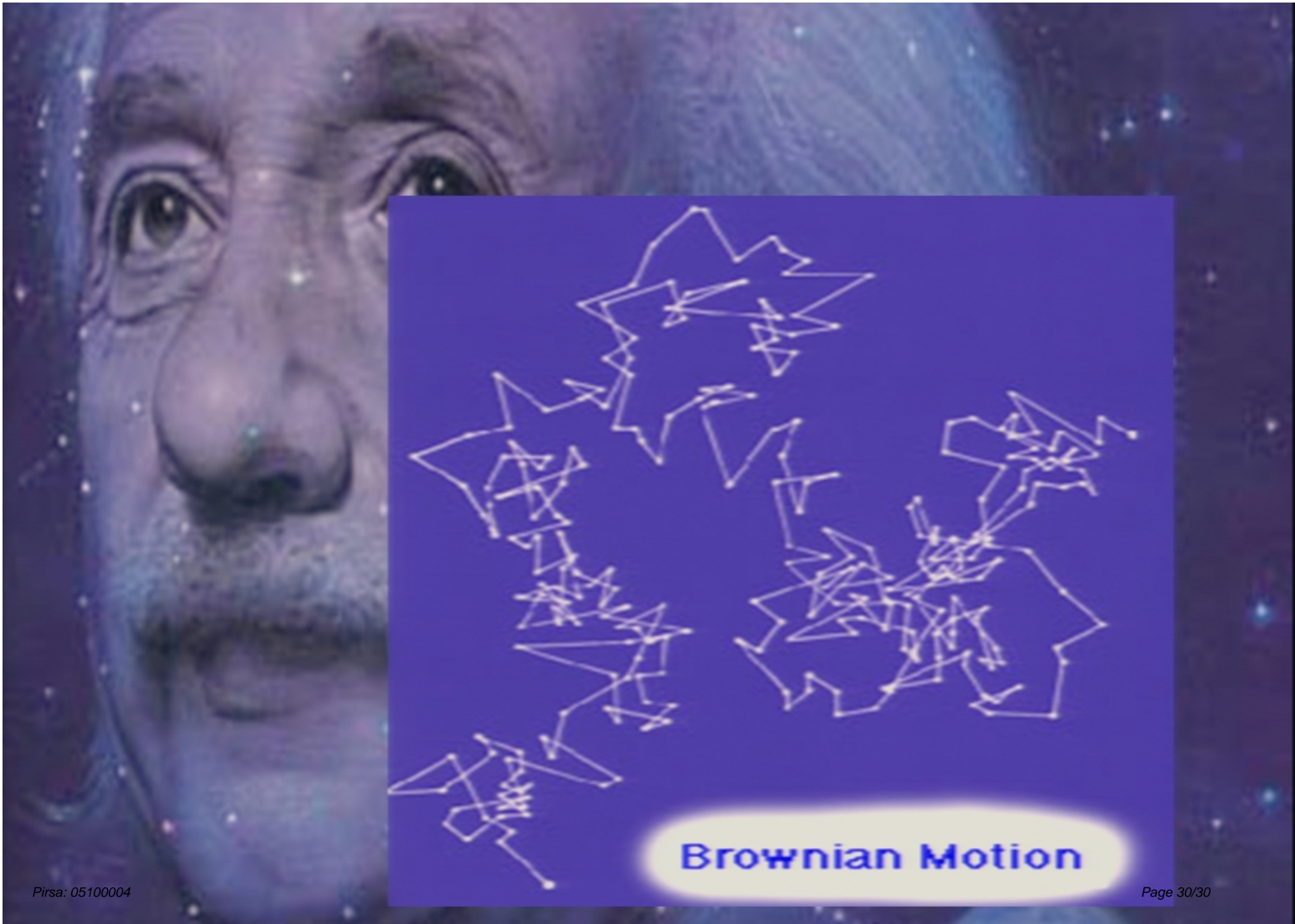




COFFEE



CREAM



**Brownian Motion**