

Title: Quantum Mechanics 17 - Quantum Teleportation " A Love Story

Date: Aug 10, 2008 03:30 PM

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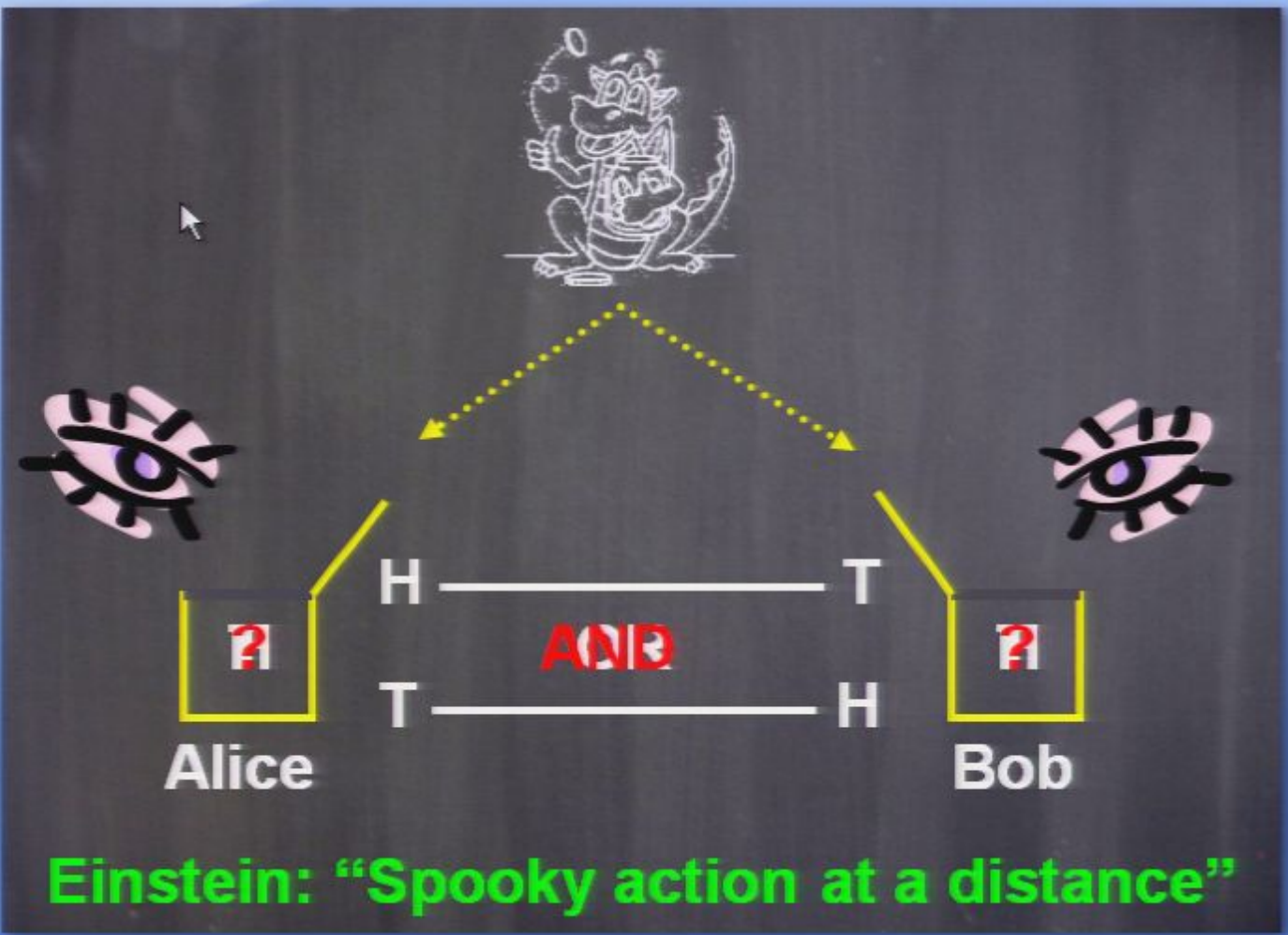
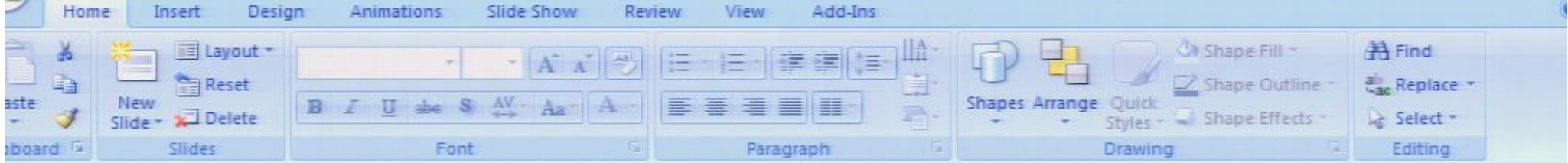
Abstract: Quantum teleportation as a fascinating application of quantum entanglement. <br>

Learning Outcomes: <br>

• Understanding precisely what "teleportation" could mean in our quantum universe. <br>

• How quantum entanglement is the key to making quantum teleportation possible. <br>

• How a quantum teleportation machine functions.



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# Quantum Teleportation

# Quantum Teleportation

...A Lo's 2t / P

# Quantum Teleportation

## *...A Love Story*











Schrödinger's Cat



Schrödinger's Cat



Schrödinger's Cat





Schrödinger's Cat





Schrödinger's Cat



Schrödinger's Cat



Schrödinger's Cat





Schrödinger's Cat



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Schrödinger's Cat



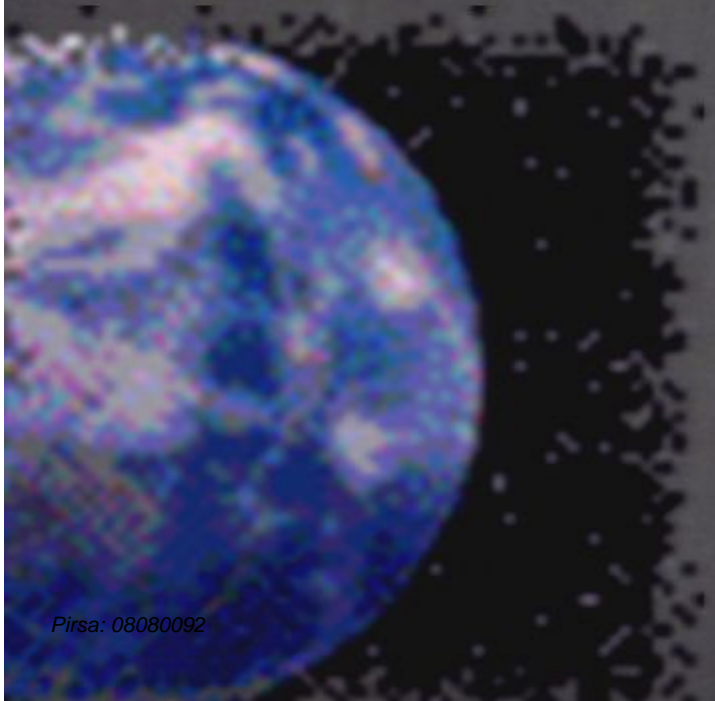


Schrödinger's Cat



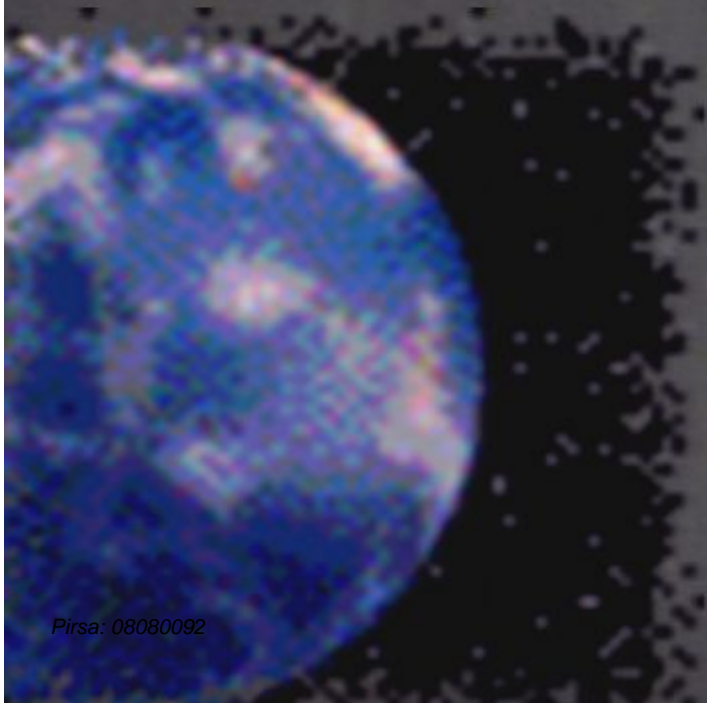


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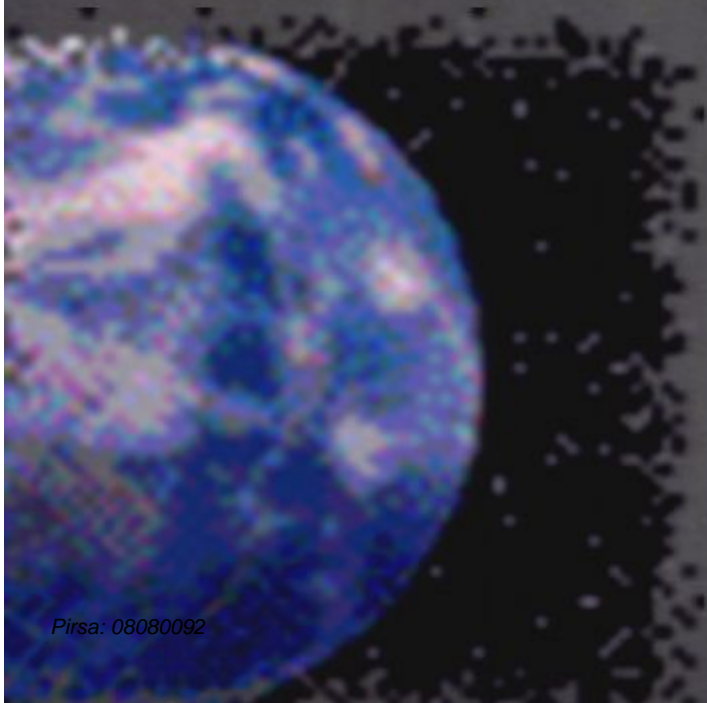






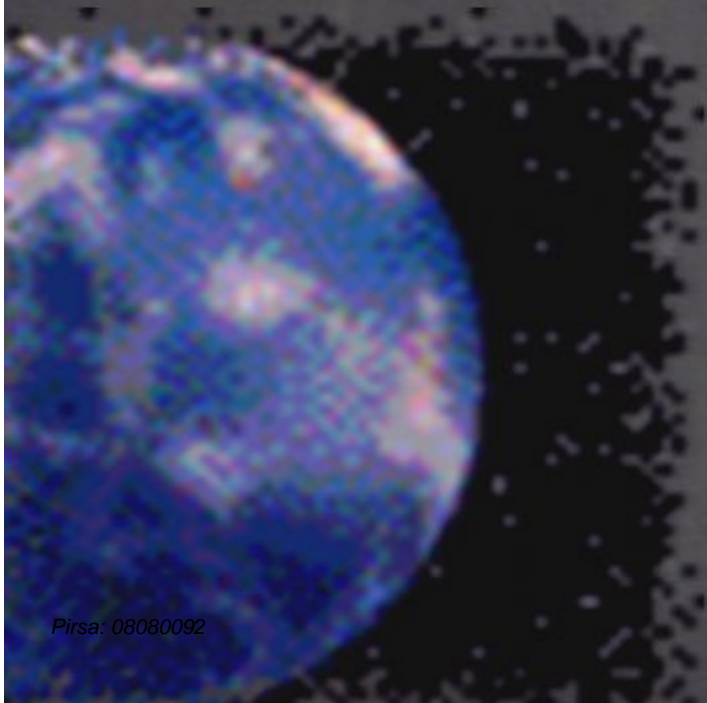






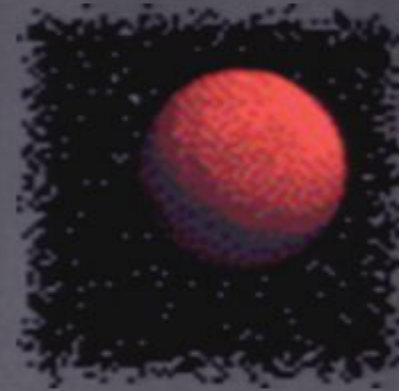
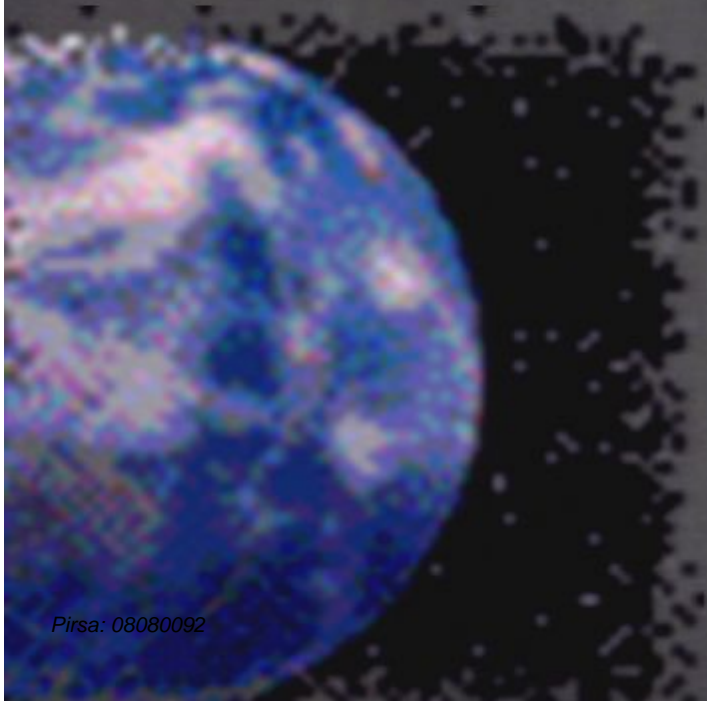


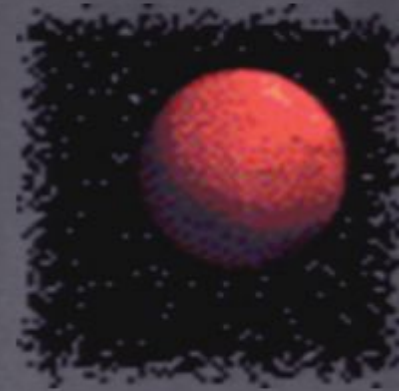




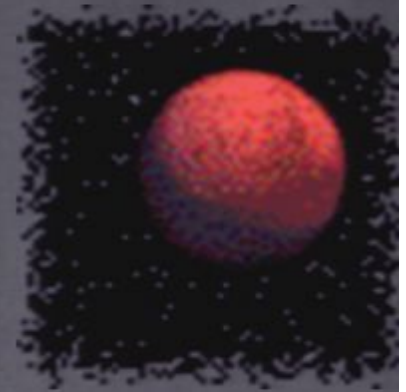
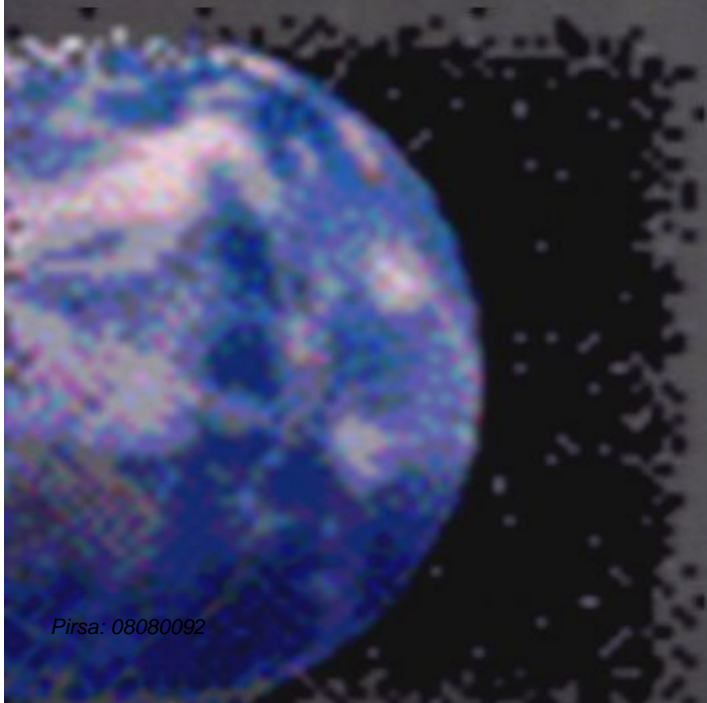


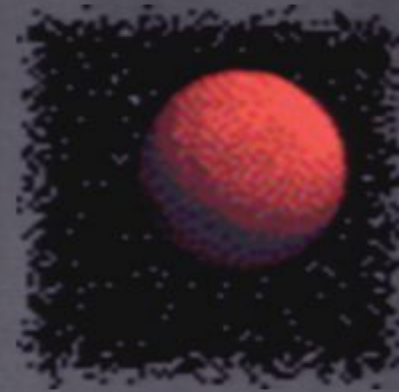


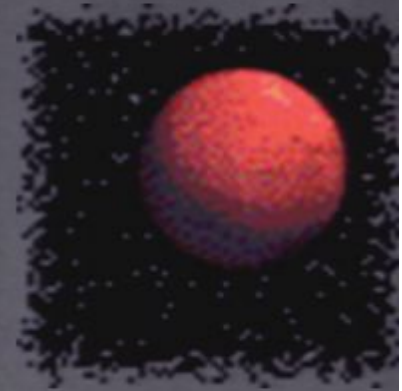
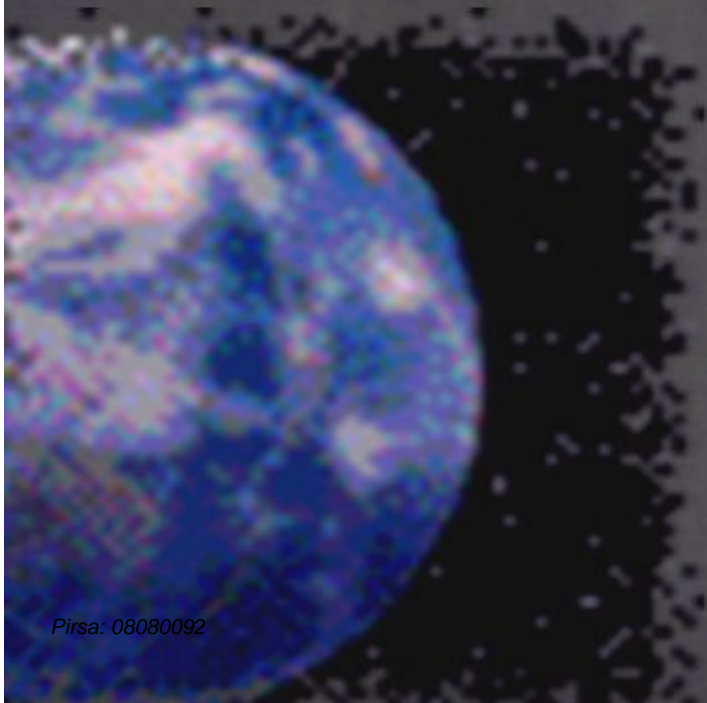




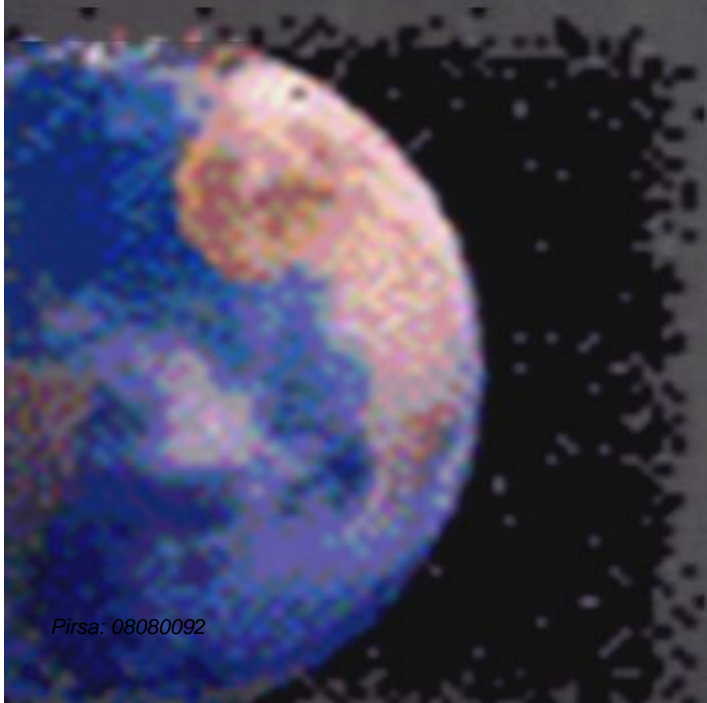


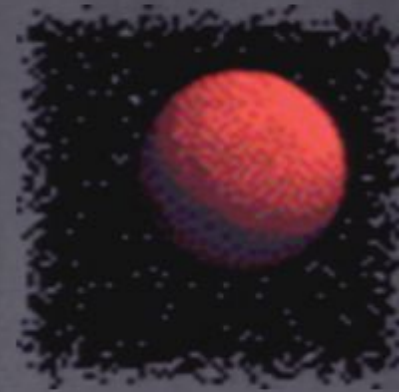
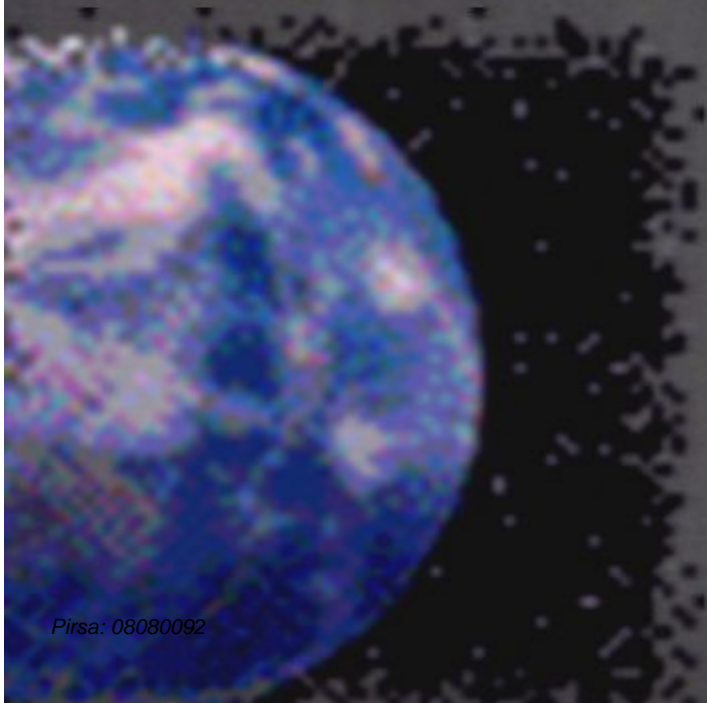


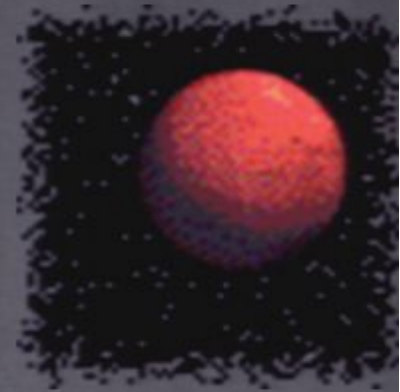




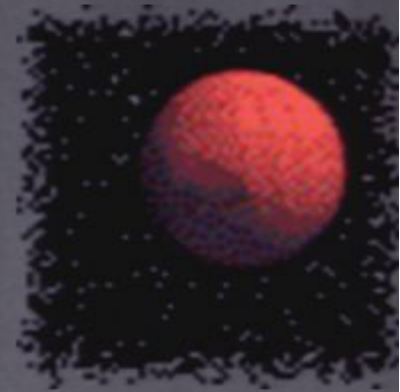
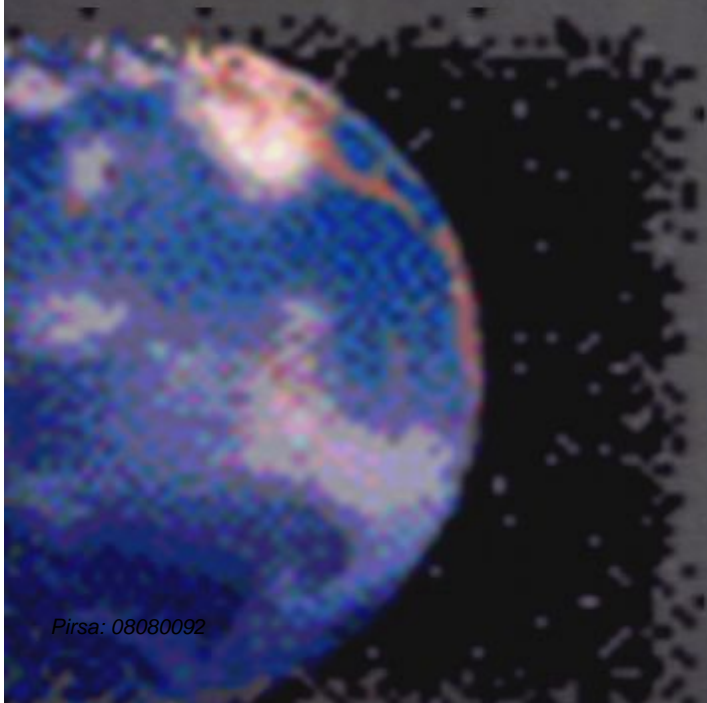


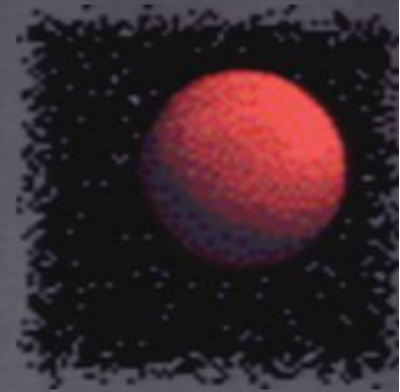
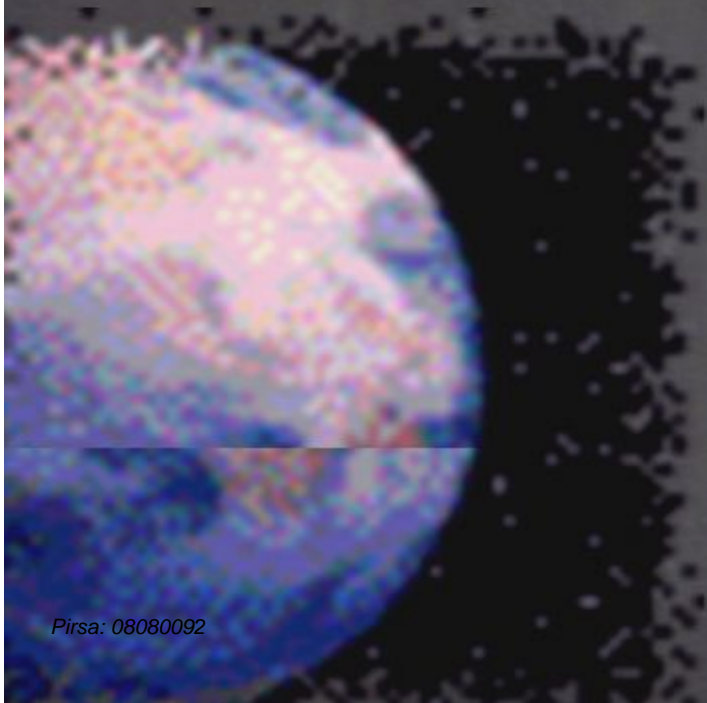


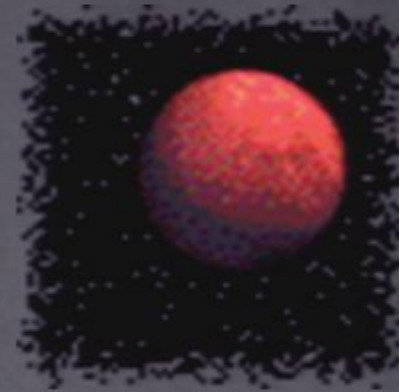
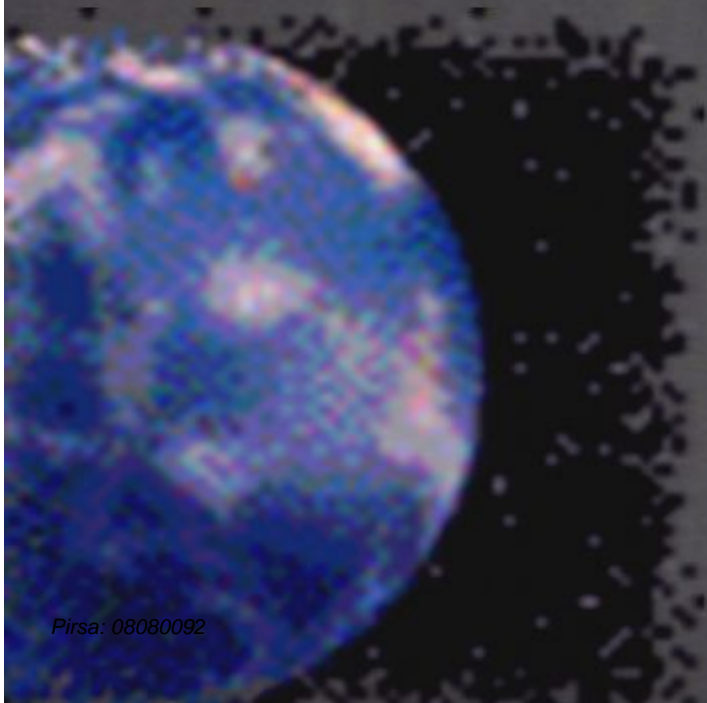




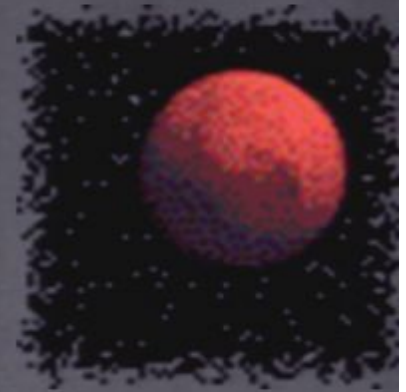


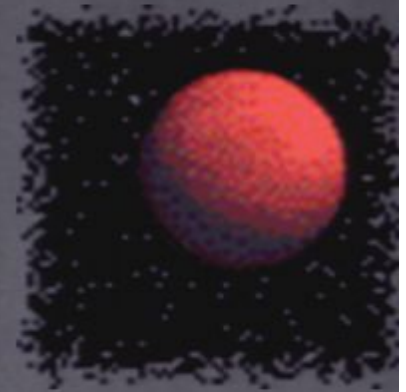
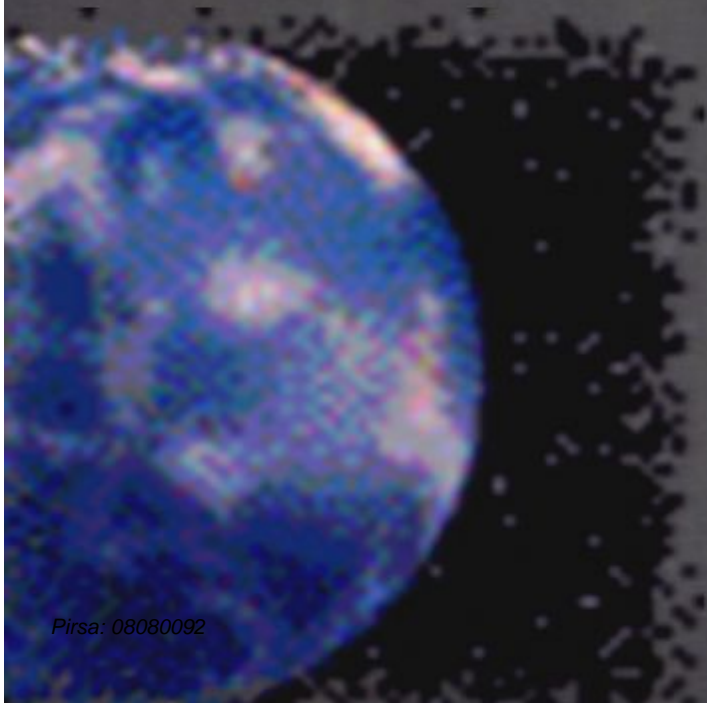


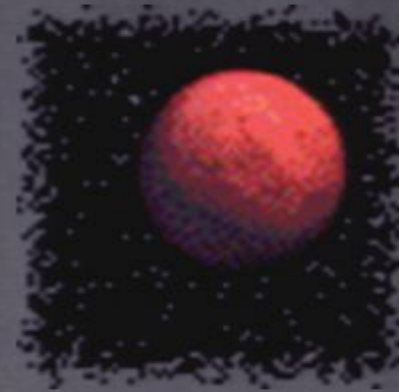
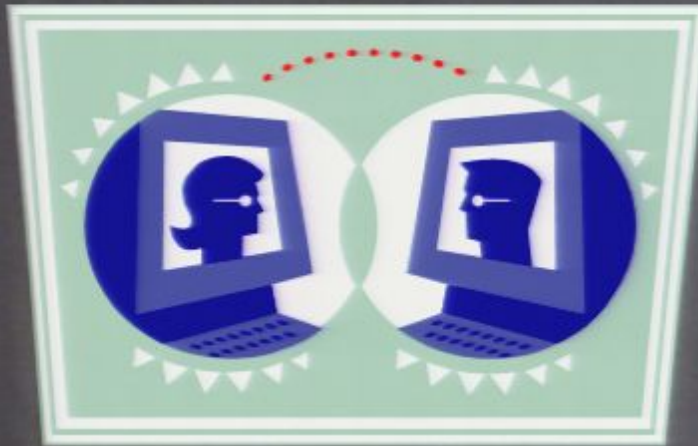




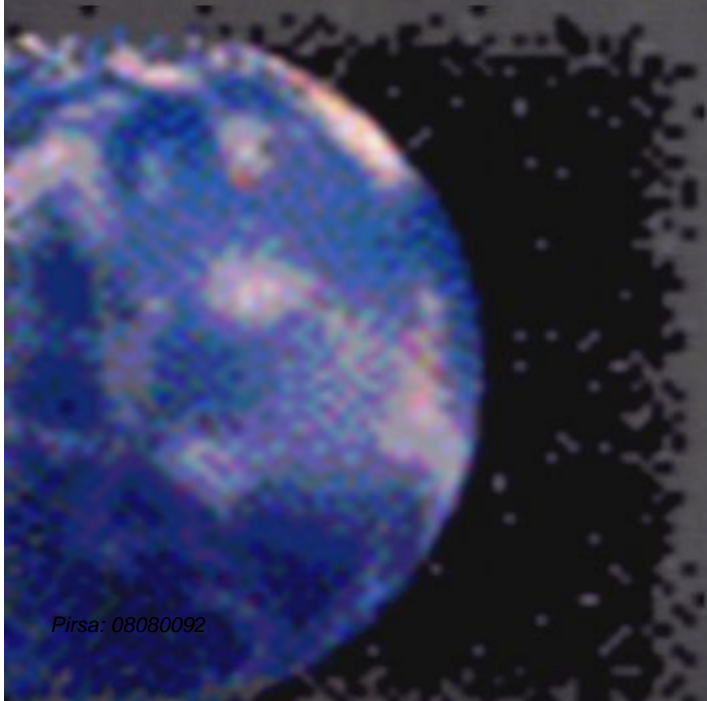
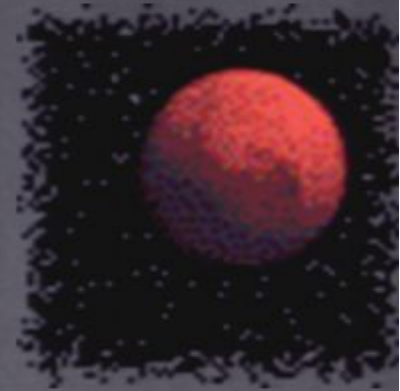
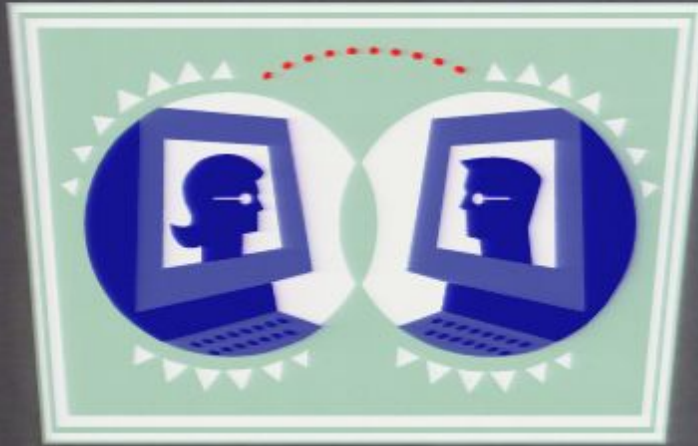


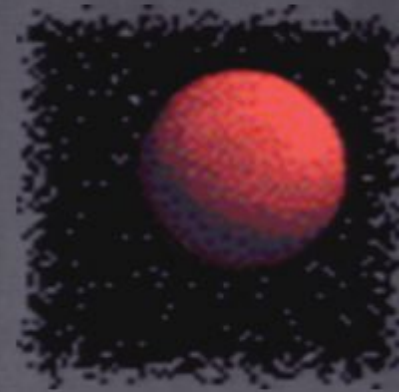
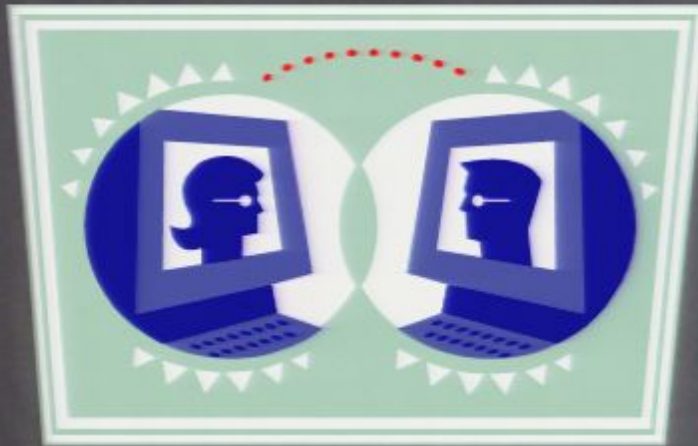


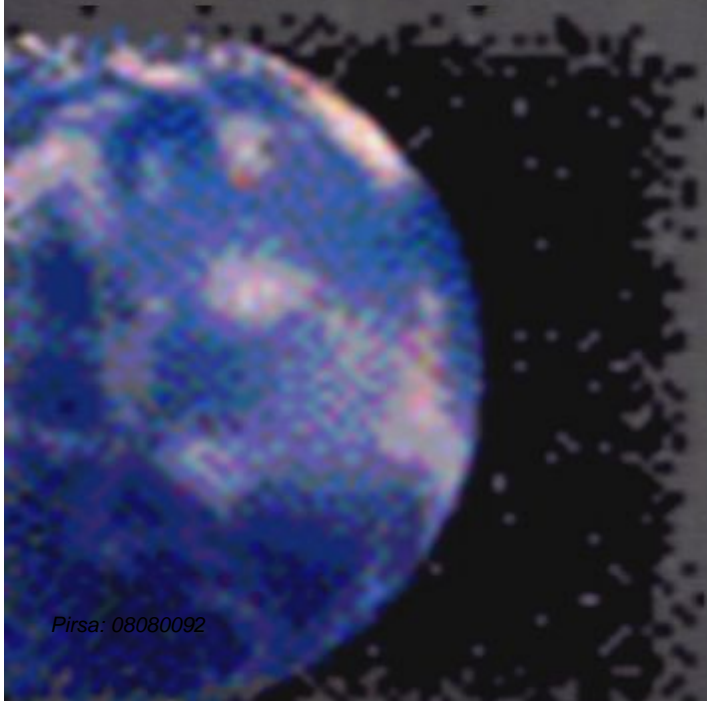
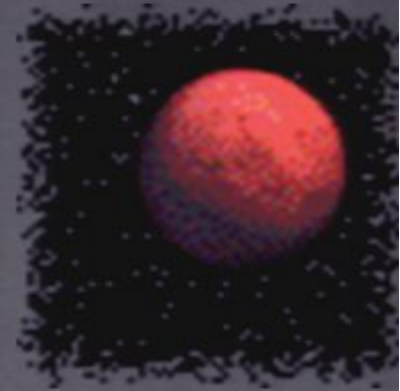
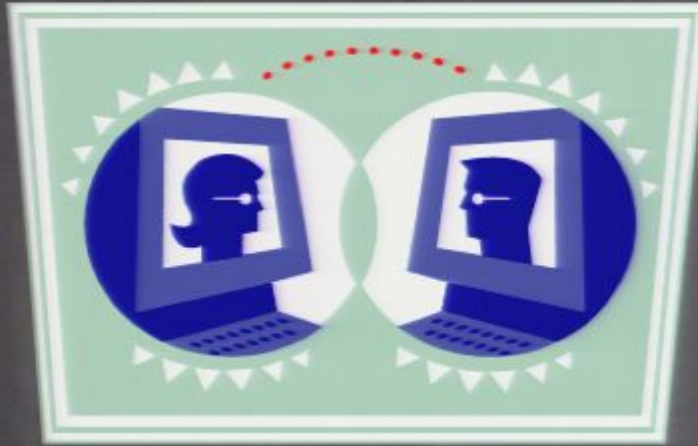




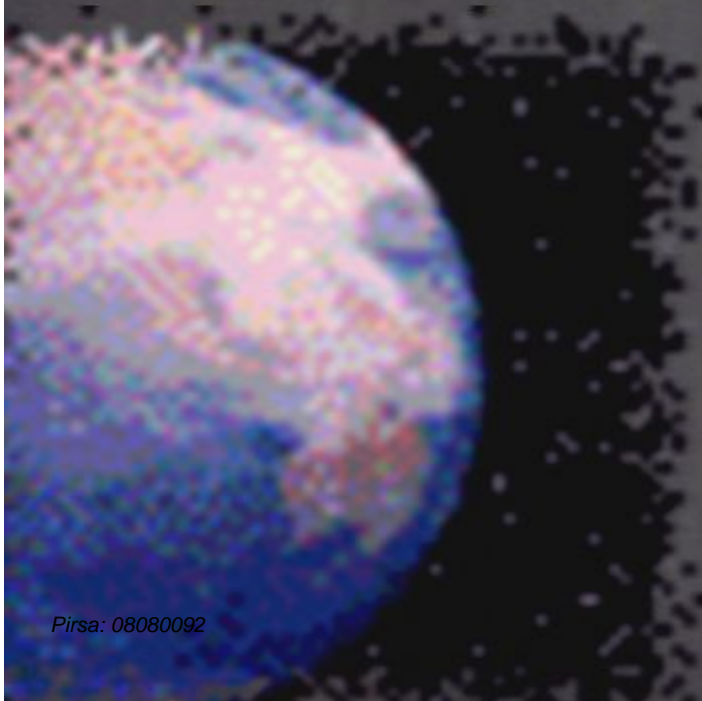
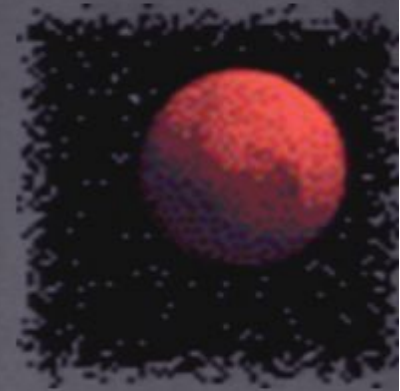
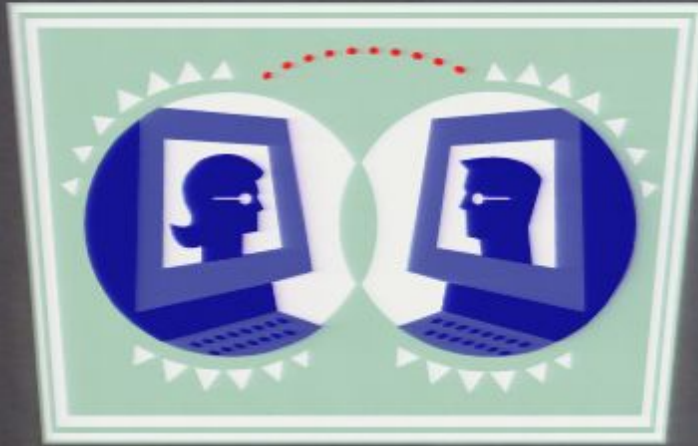


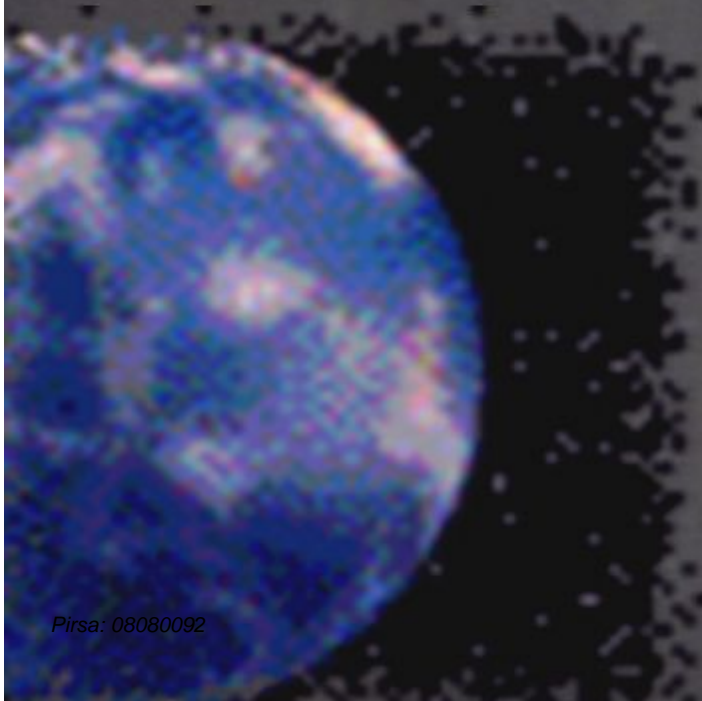
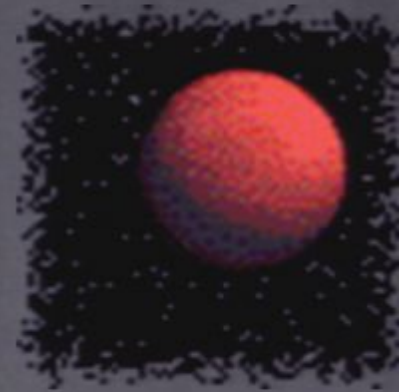
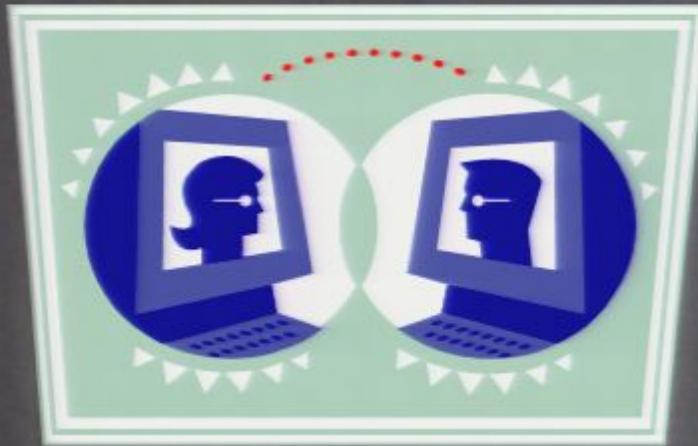


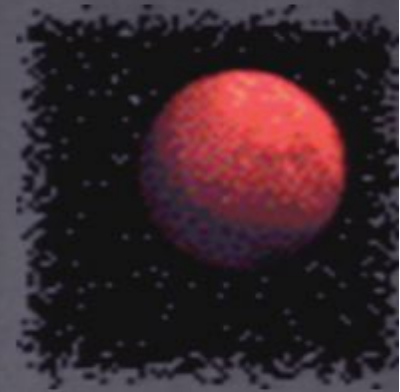
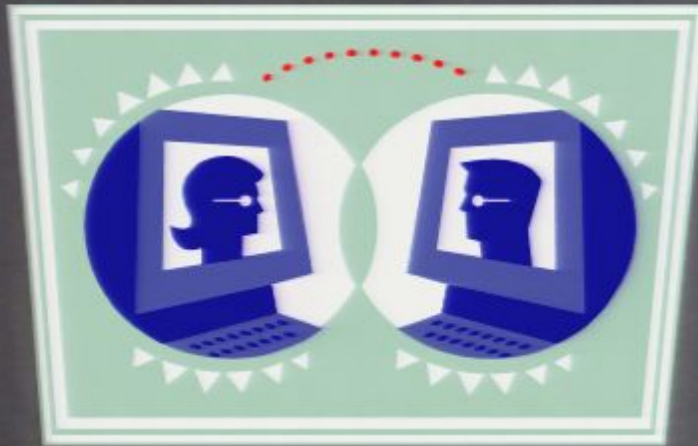




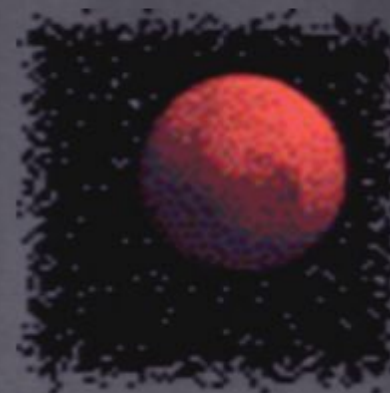
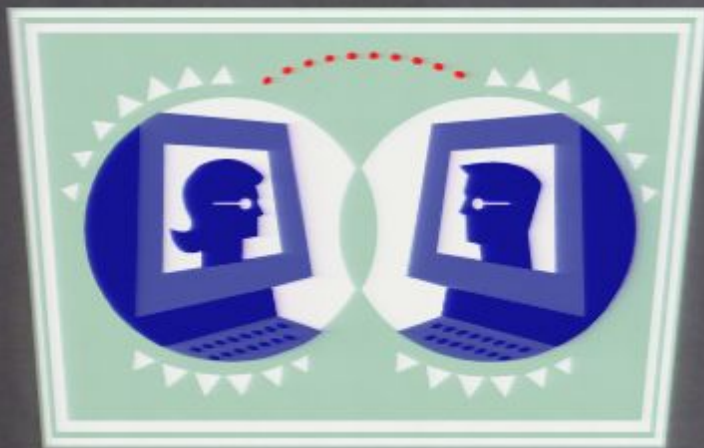


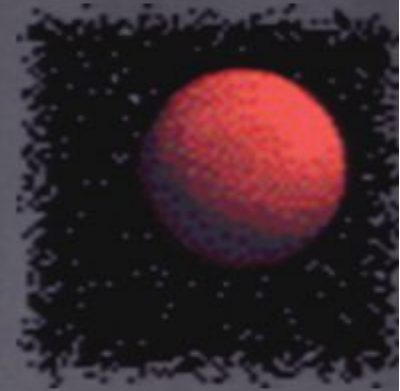
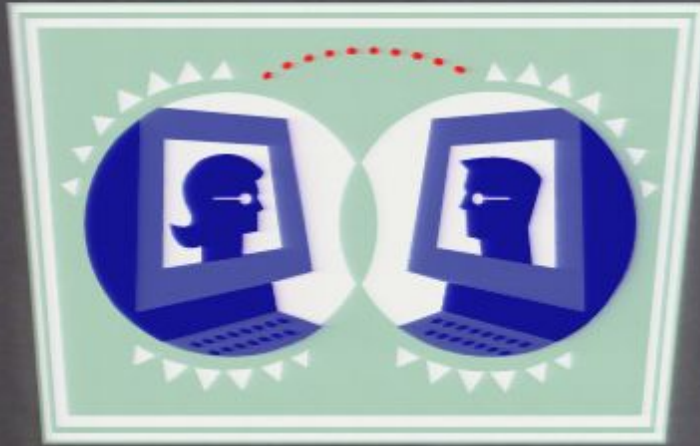


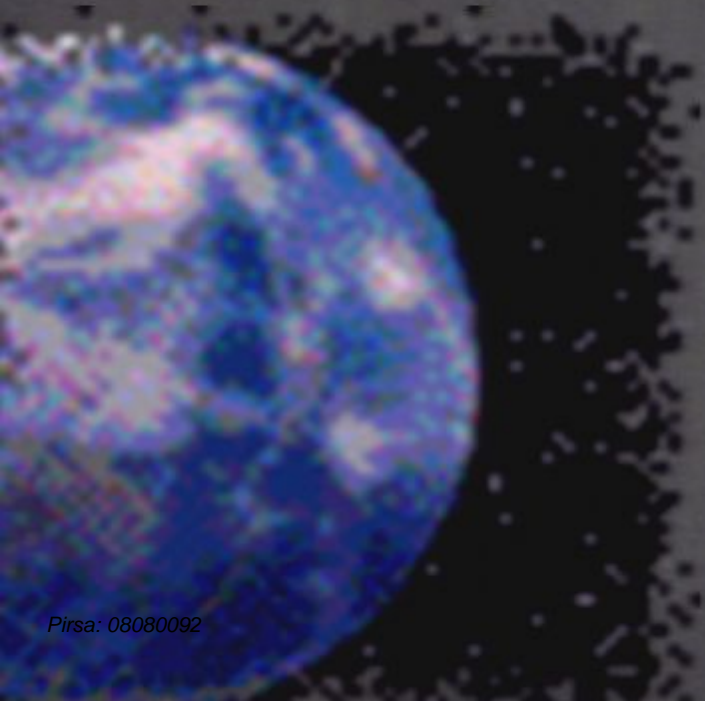
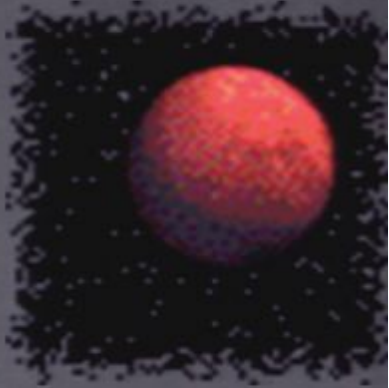




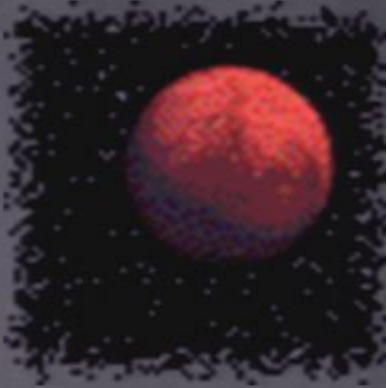


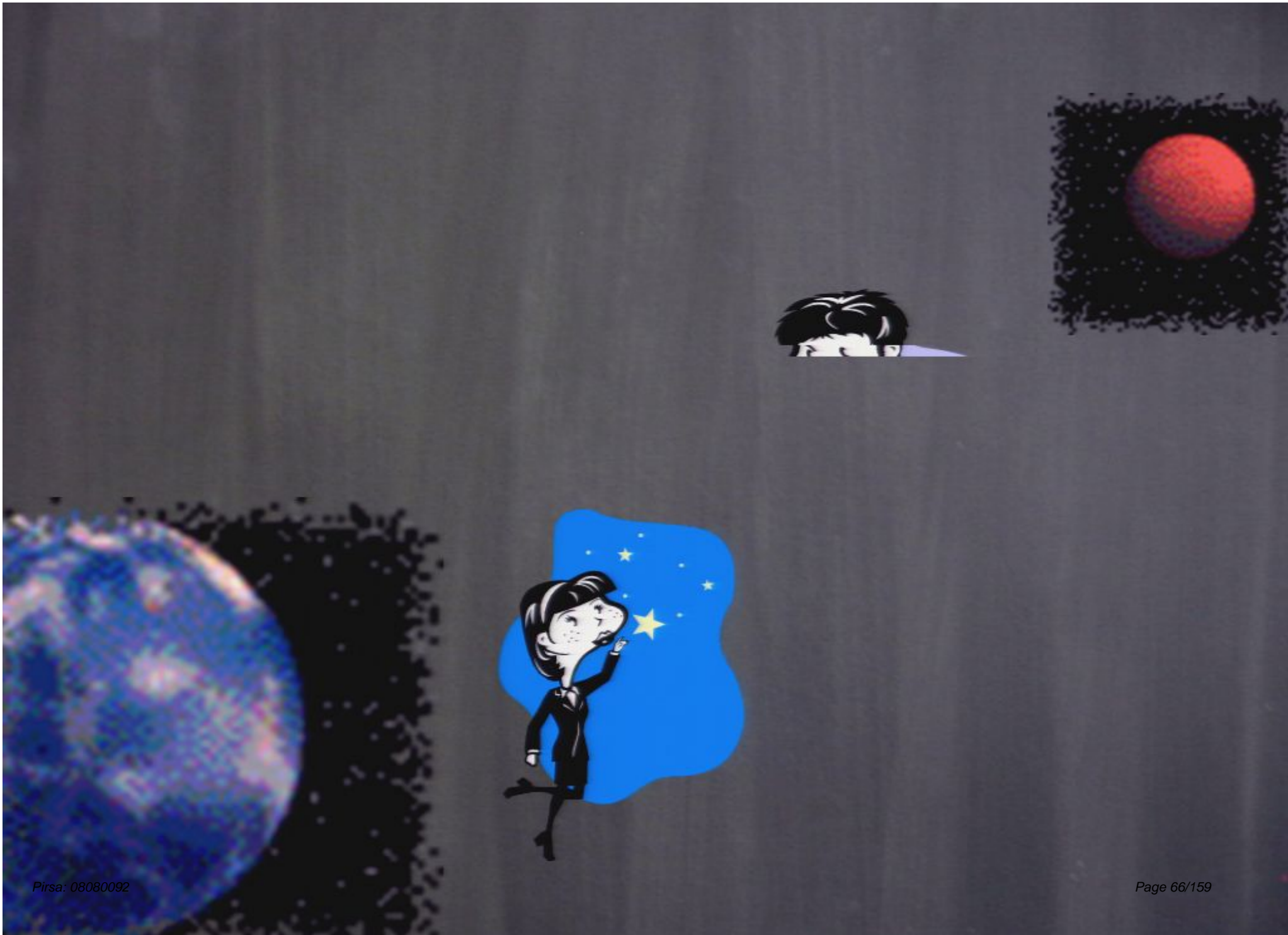


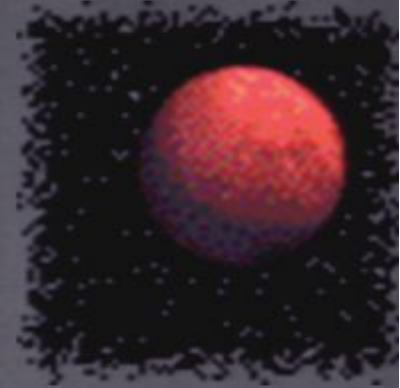




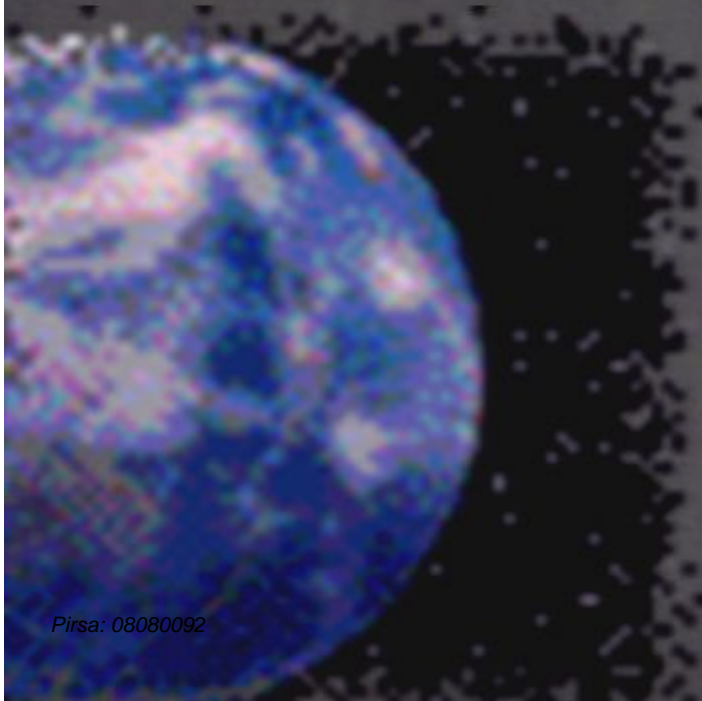


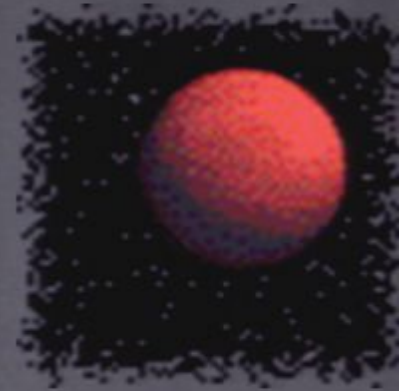


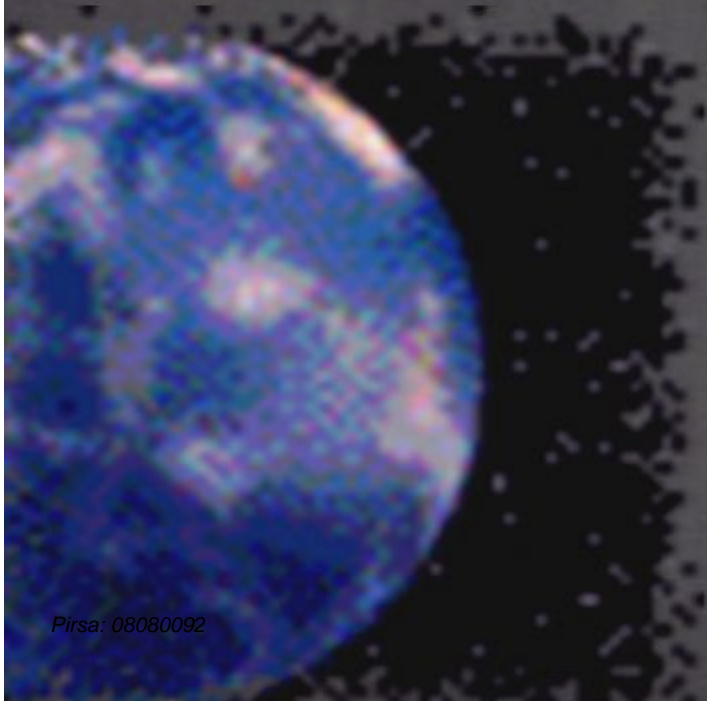
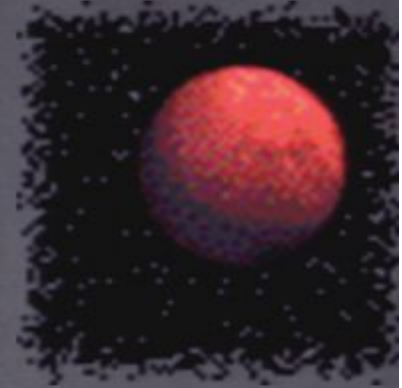




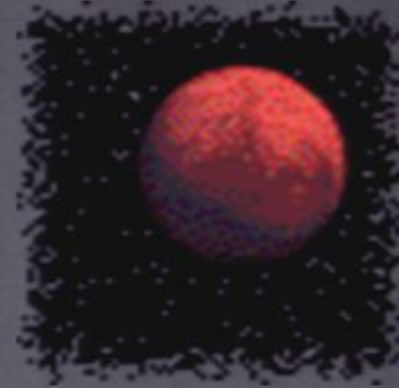


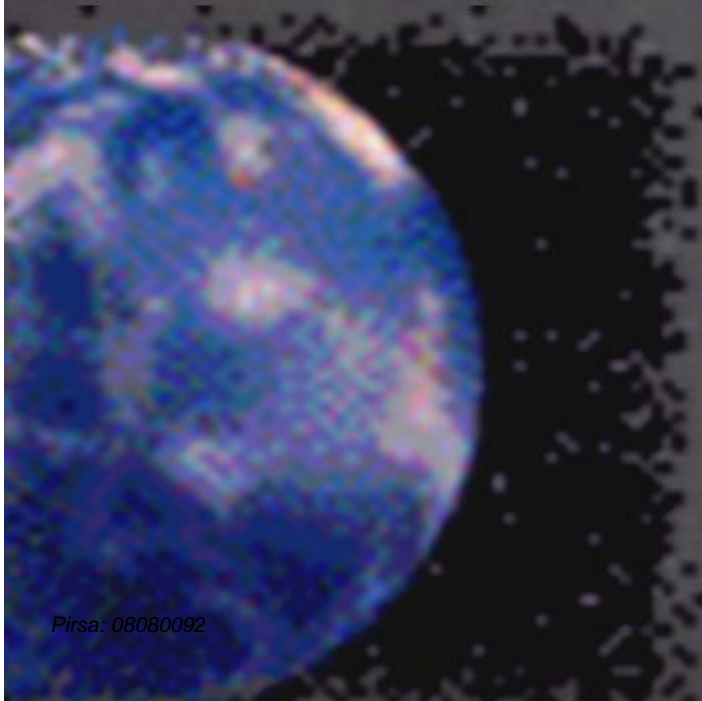
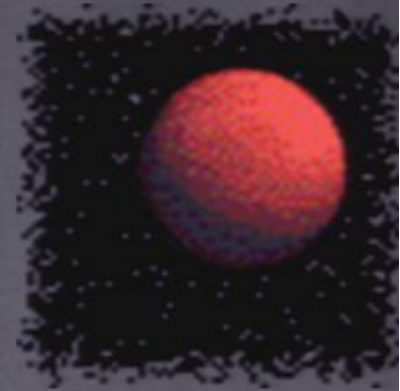


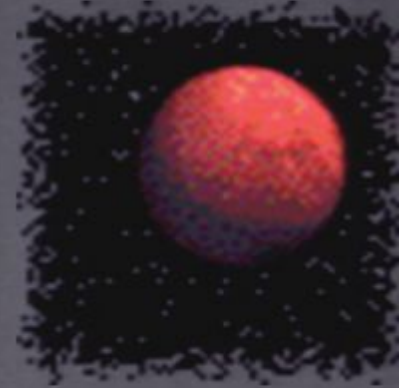




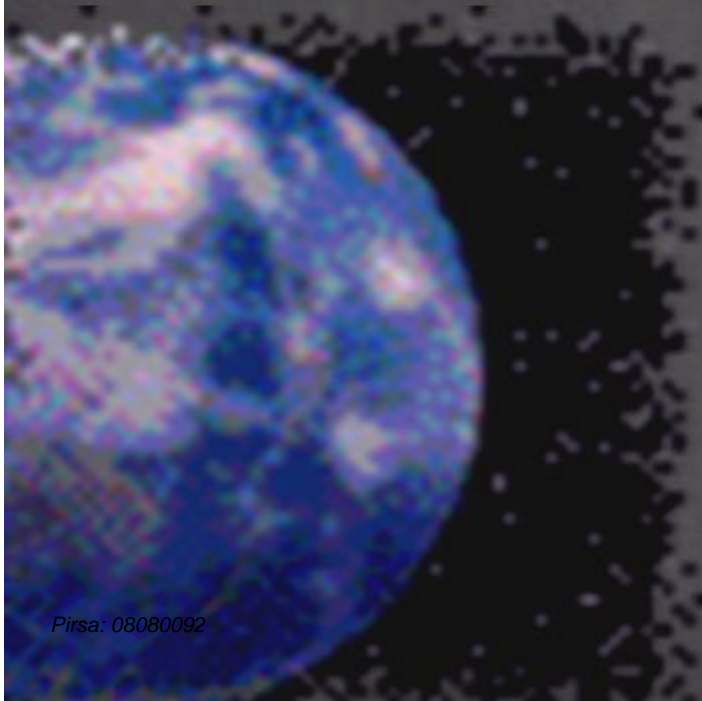
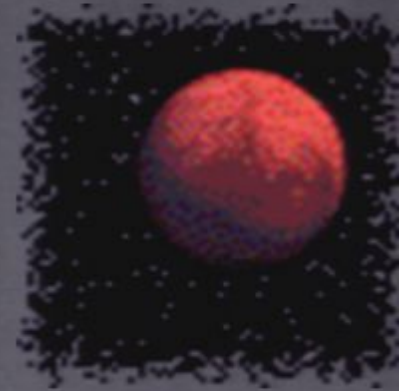


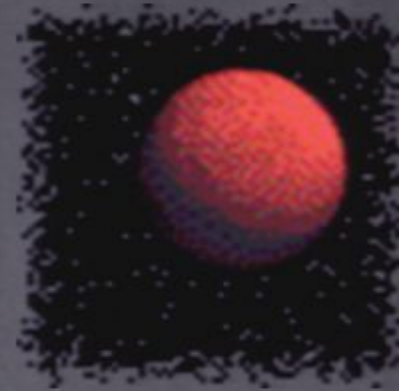


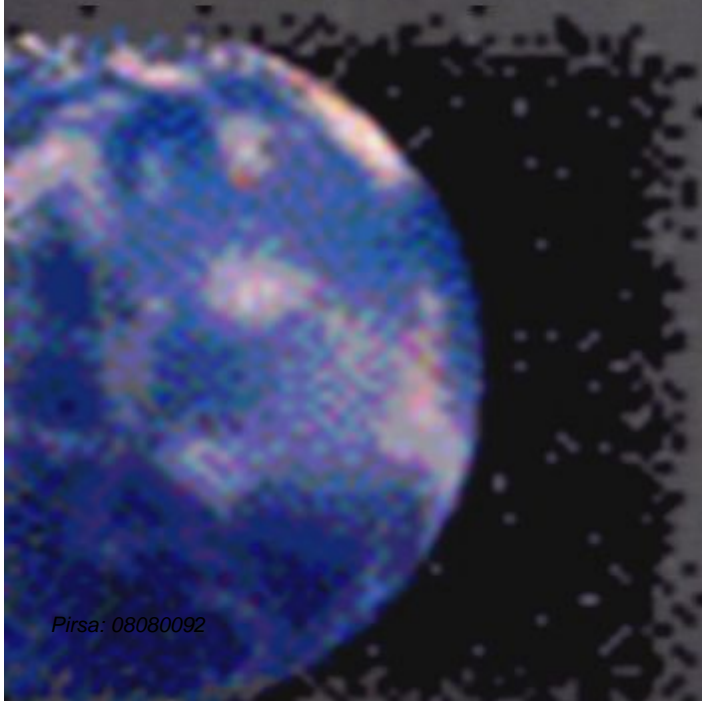
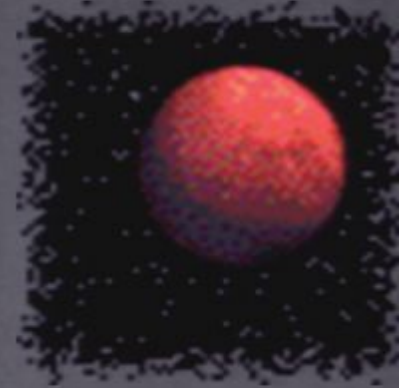




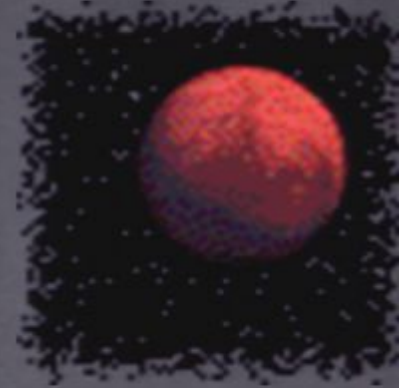


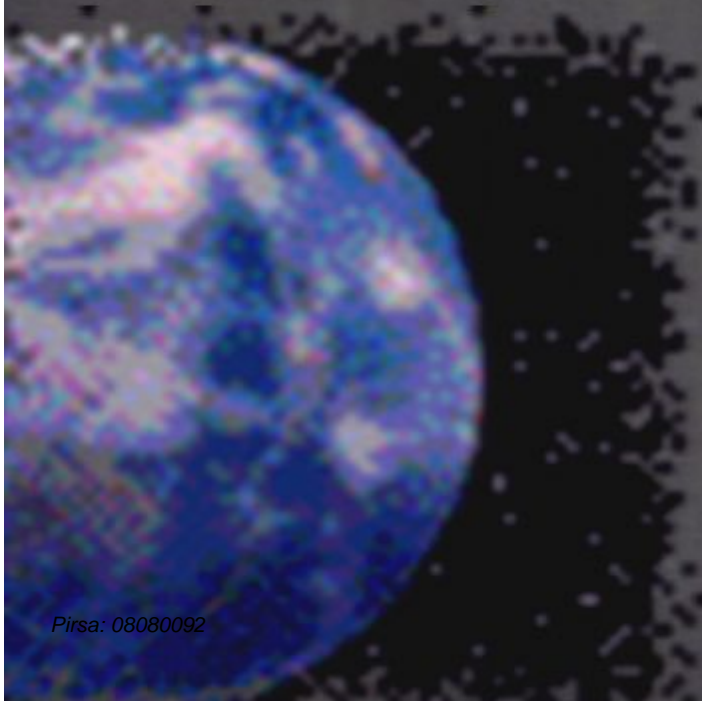
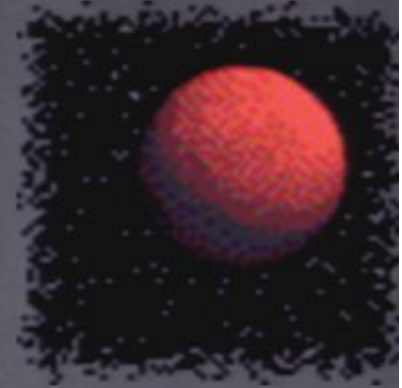


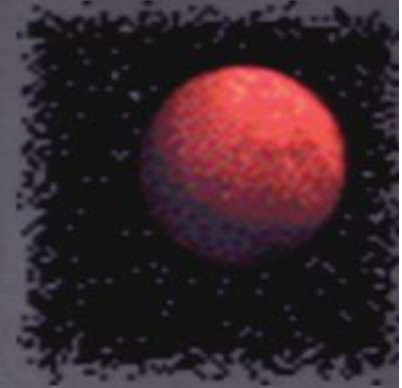




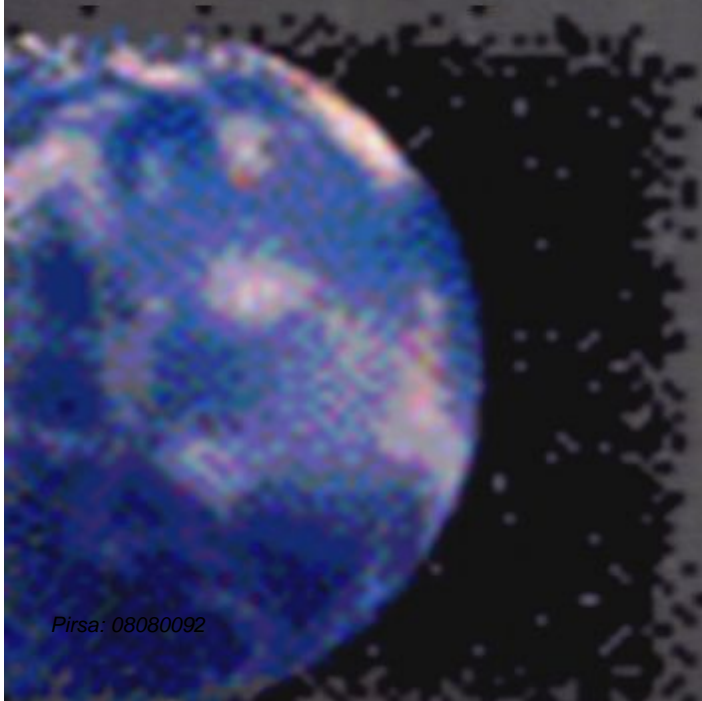
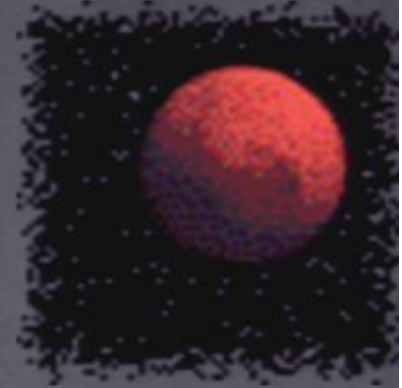


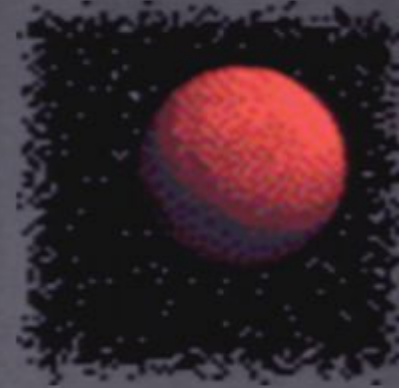


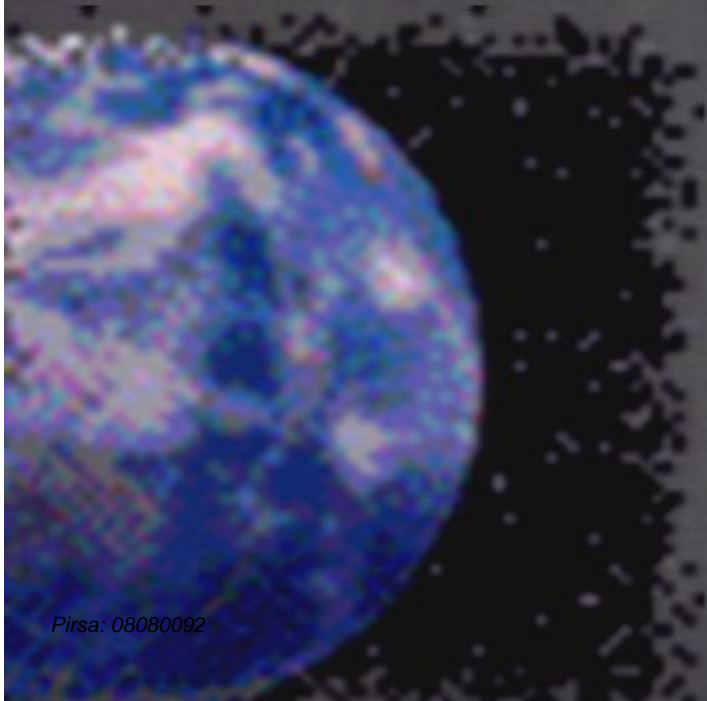
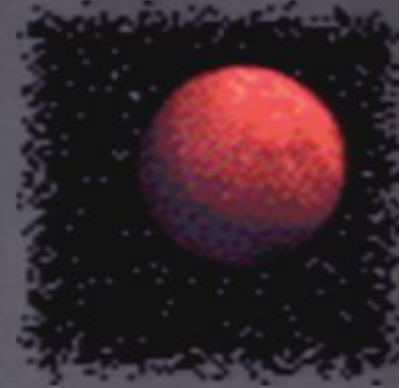




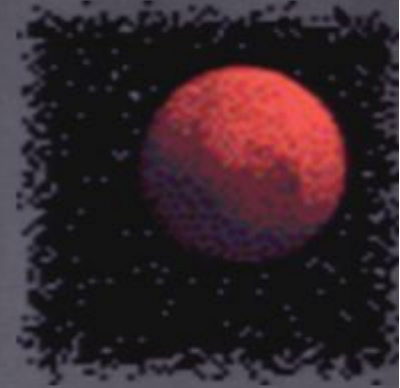


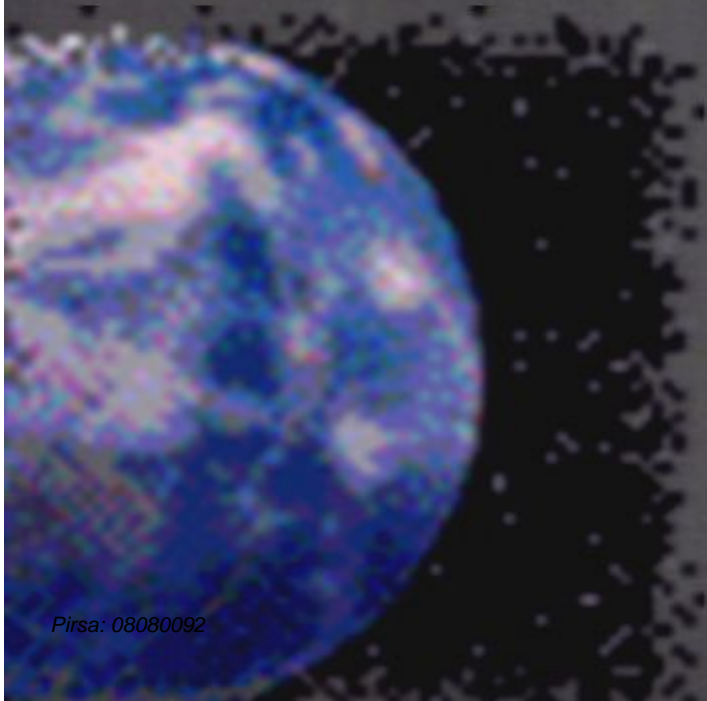
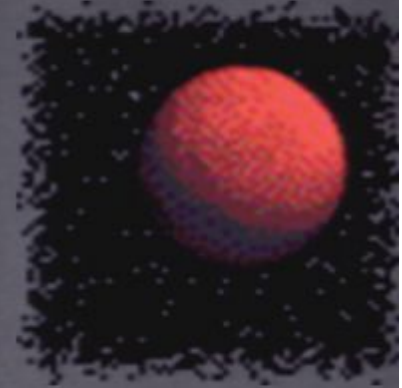




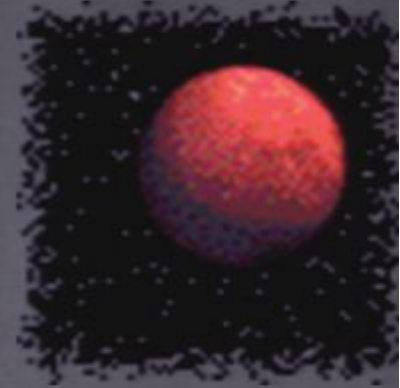














What do we mean by "teleportation"?

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Disappear Here

# What do we mean by "teleportation"?



# What do we mean by "teleportation"?



Reappear There



# What do we mean by "teleportation"?



- ✓ Must be a time delay ( $<$  speed of light)

# What do we mean by "teleportation"?



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Disassemble into  
individual atoms...



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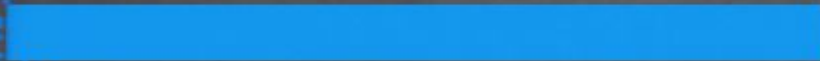
Disassemble into  
individual atoms...

...beam the  
physical atoms

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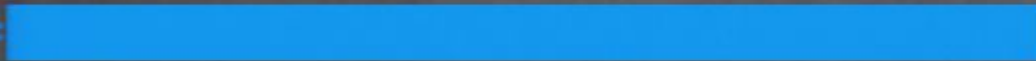
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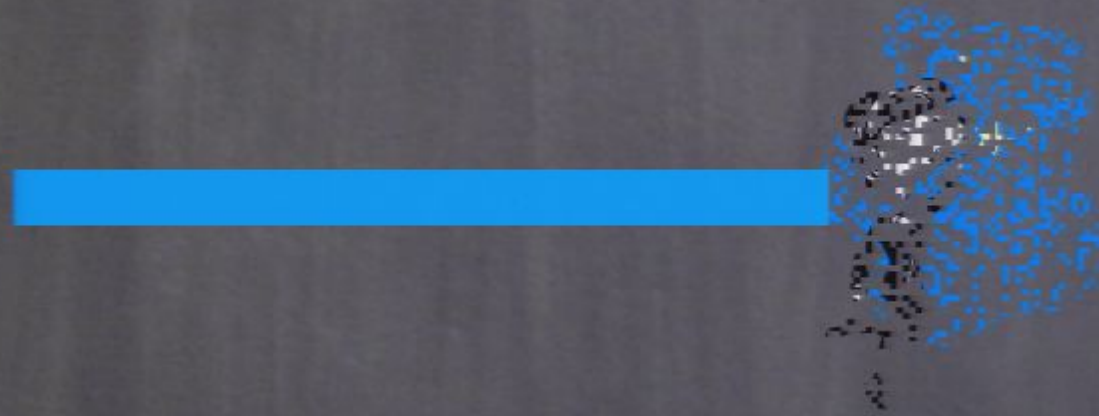
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Reassemble like giant jigsaw puzzle?

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Unnecessarily complicated!

Quantum Fact: All atoms of same type are truly identical

Need only send the information, not the atoms

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- ✓ Send only information; reassemble using atoms on Mars



# What do we mean by "teleportation"?



- ✓ Must be a time delay ( $<$  speed of light)
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Problem: Won't we end up with two copies of Alice?

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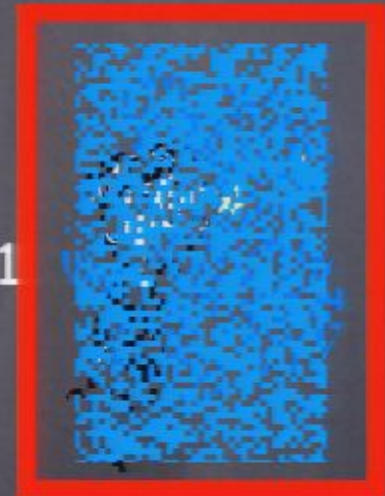


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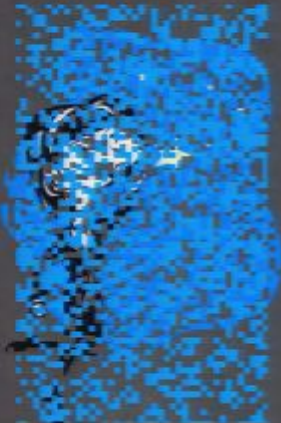


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There can be only one Alice →



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Question: How do we measure the "quantum information" in Alice's atoms?

Answer: We can't!

Quantum Facts: *Heisenberg Uncertainty limits the amount of information that can be extracted*  
*Worse: Certain quantum information cannot be measured at all!*



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If we can't even measure the information we wish to send, doesn't this mean quantum teleportation is impossible?

NO: In 1993 Charles Bennett *et al* discovered that quantum entanglement could be used to send the information without actually measuring it!



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© Quantum Teleportation and Speed of Light Experiment



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# Quantum Teleportation

Here's how it works:

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Warning: The Following is *Science Fiction*



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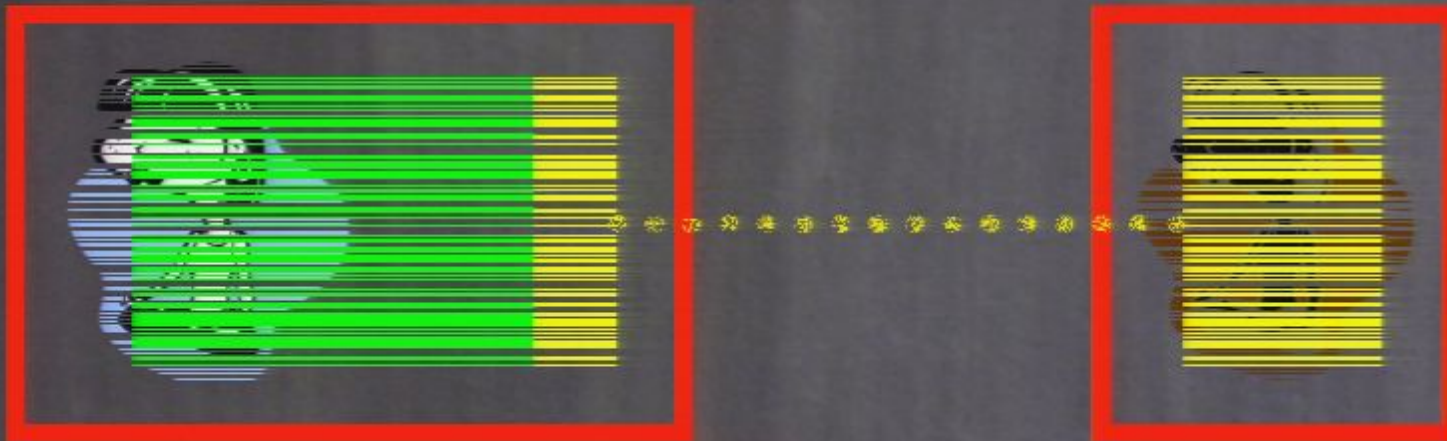
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101101101
001101110
101101101
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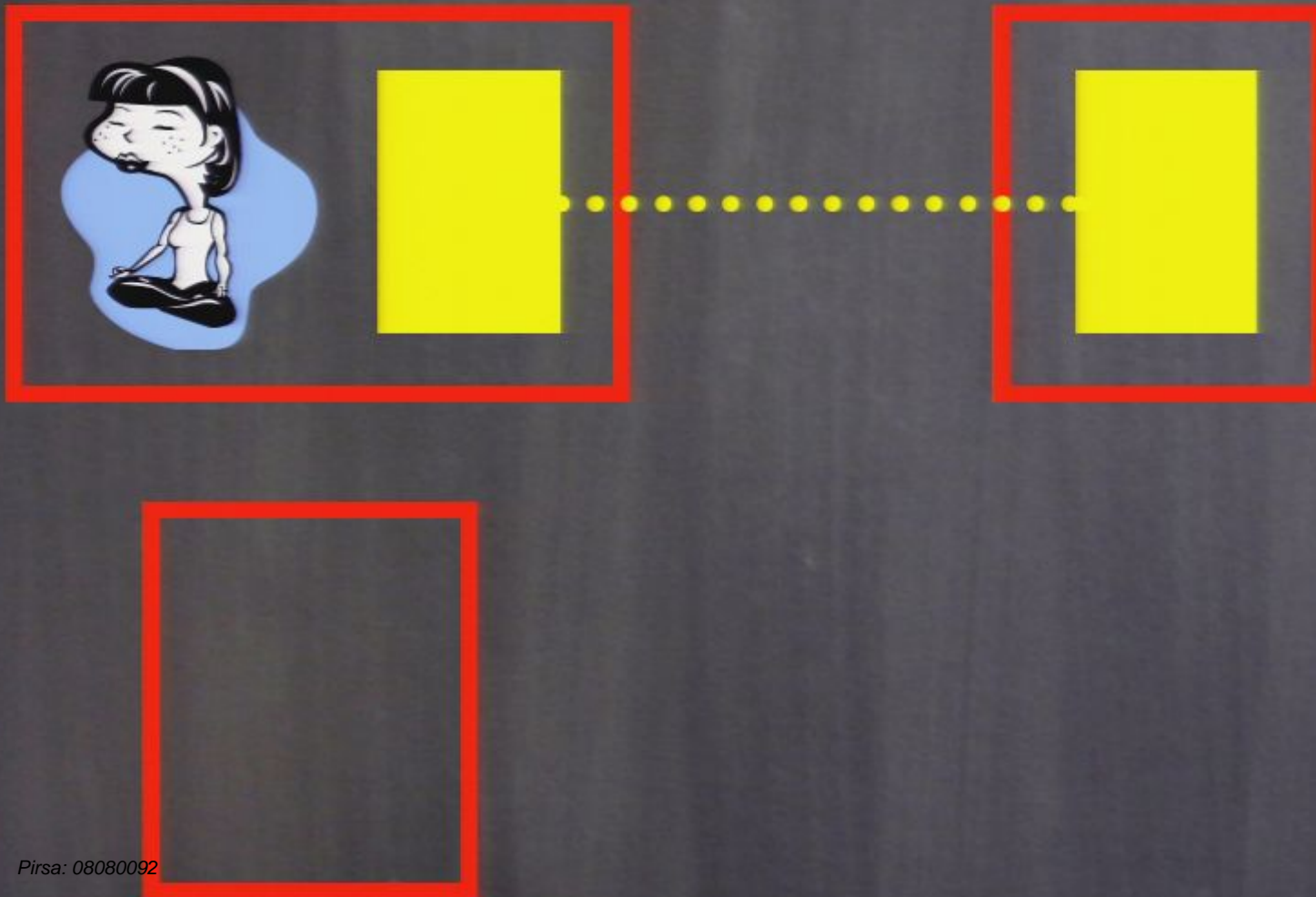
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010111010  
011011011  
101101101  
001101110  
101101101
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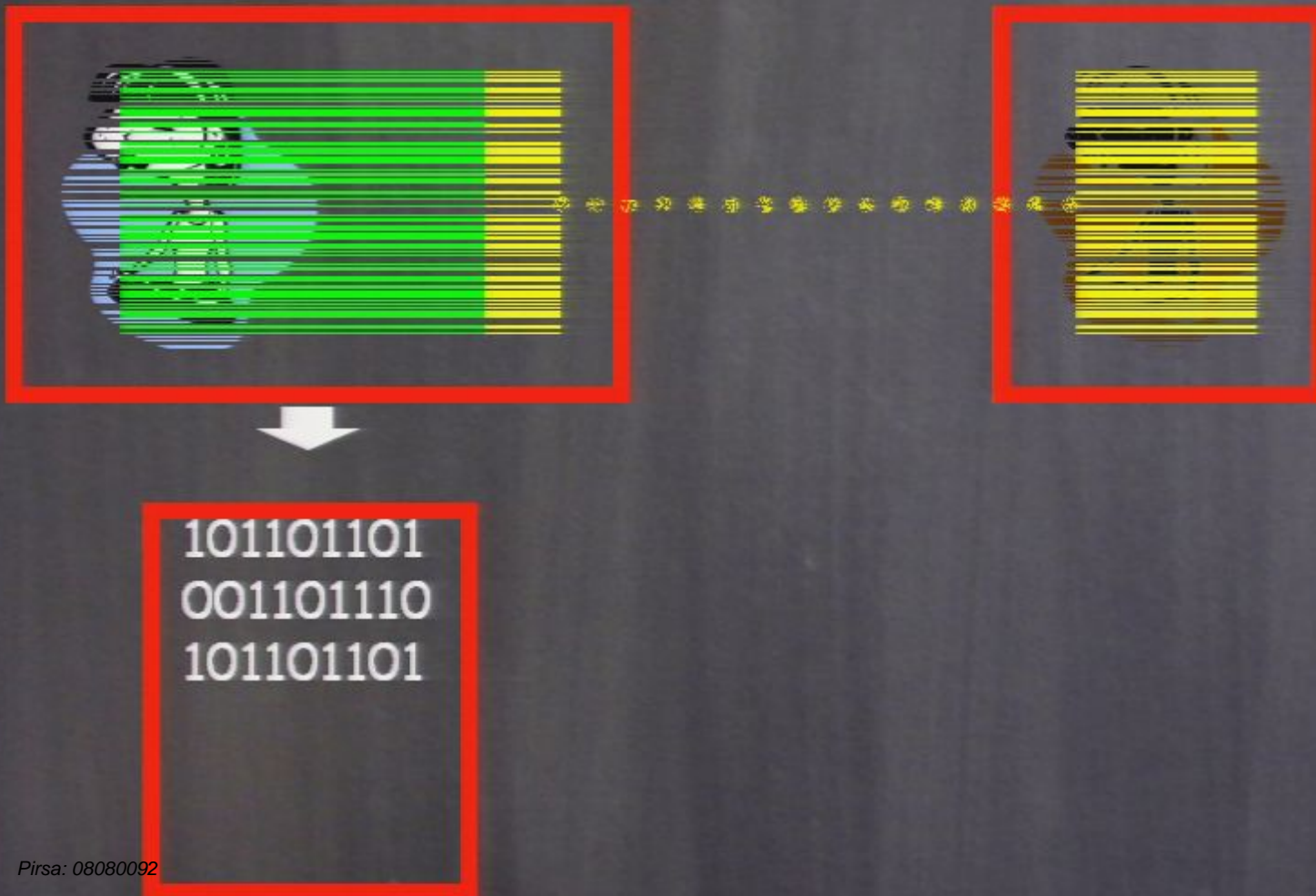
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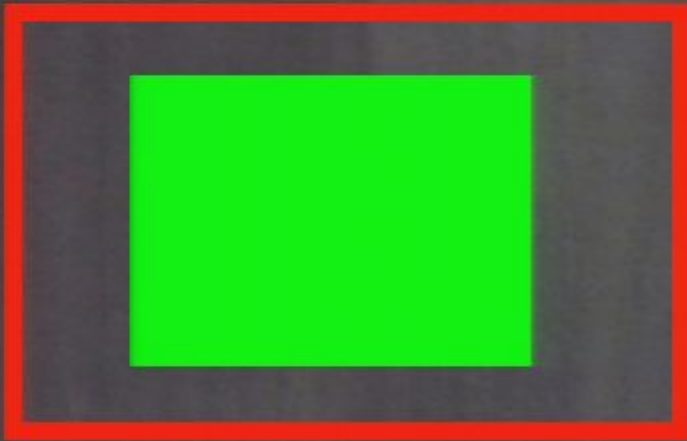
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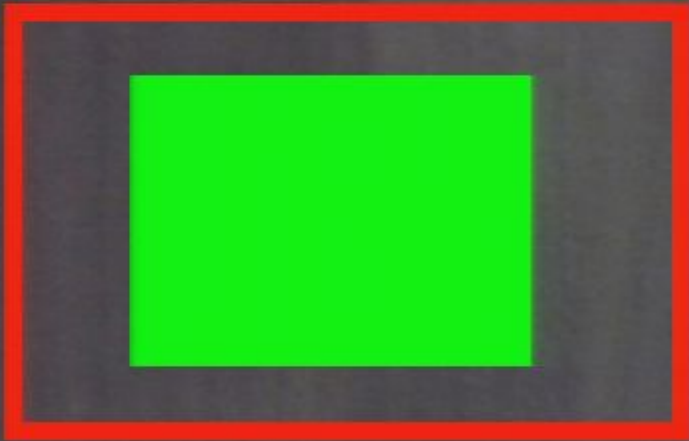
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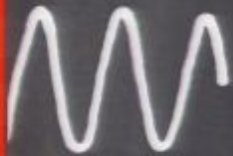
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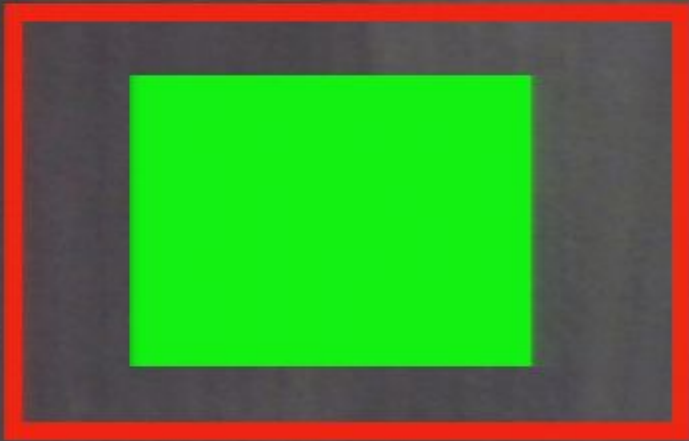
101101  
010111  
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101101  
001101  
101101





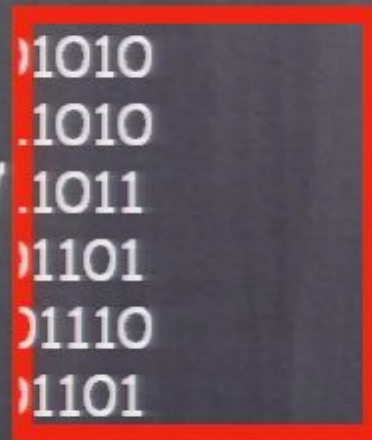
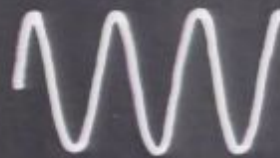
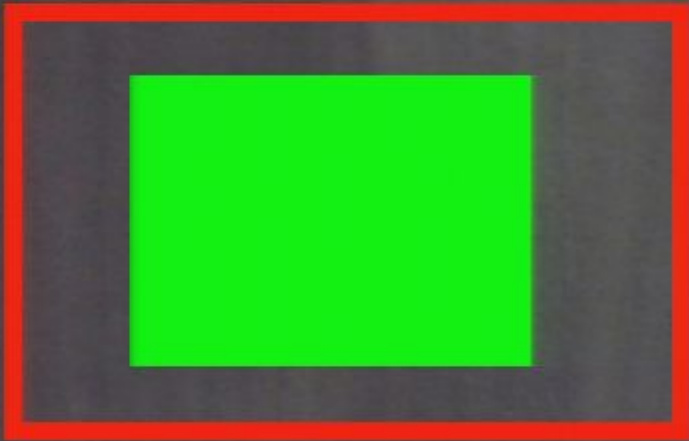
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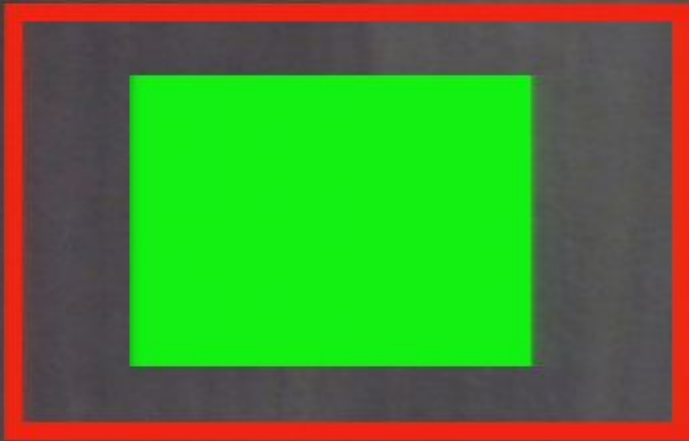
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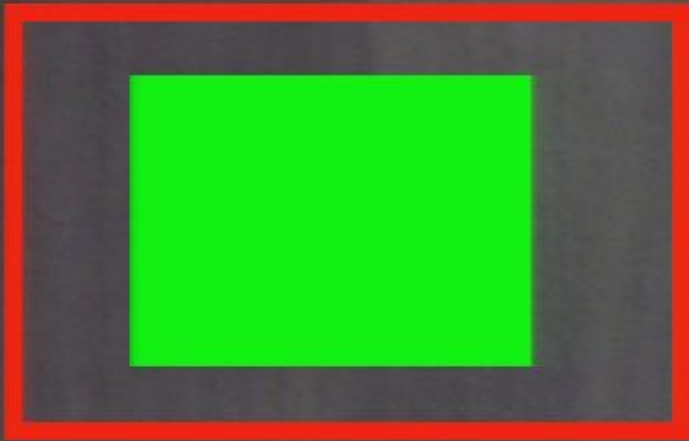
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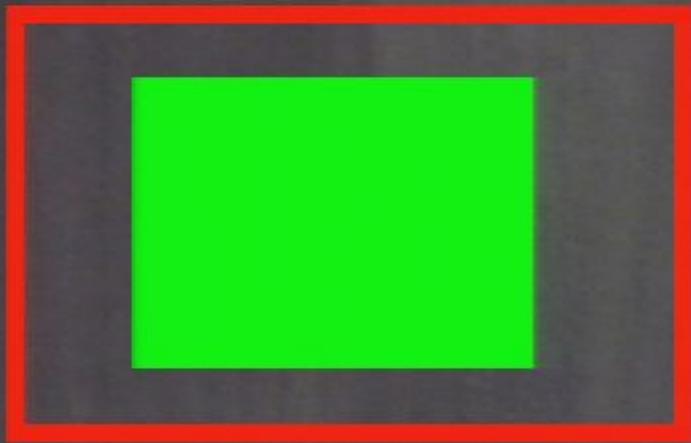
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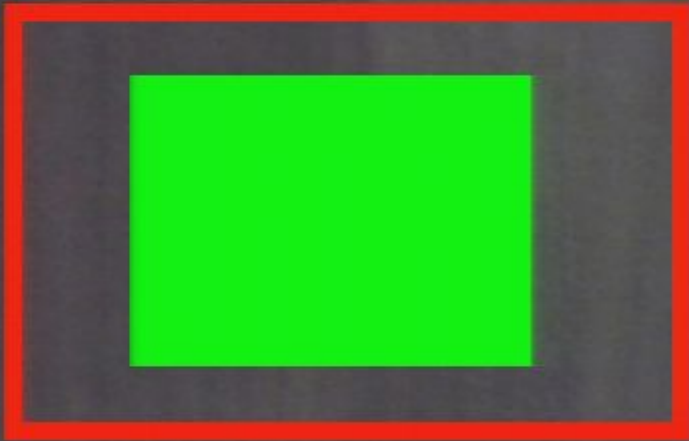
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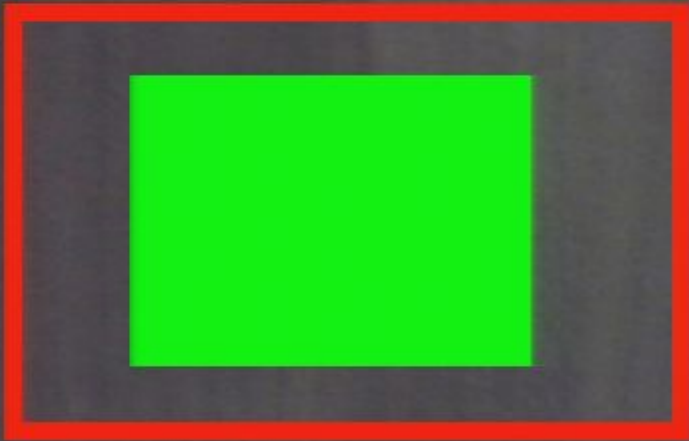
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*A quantum identical version of Alice on Mars!*



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Important:

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But in our weird quantum world this amounts to the same thing...

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# Our Weird Quantum World...

...is crazier and more beautiful than we imagined,  
and the subtleties just keep getting deeper...