Title: Physics in Nature Presentation: Fire

Date: Aug 19, 2011 02:00 PM

URL: http://pirsa.pi.local/11080103

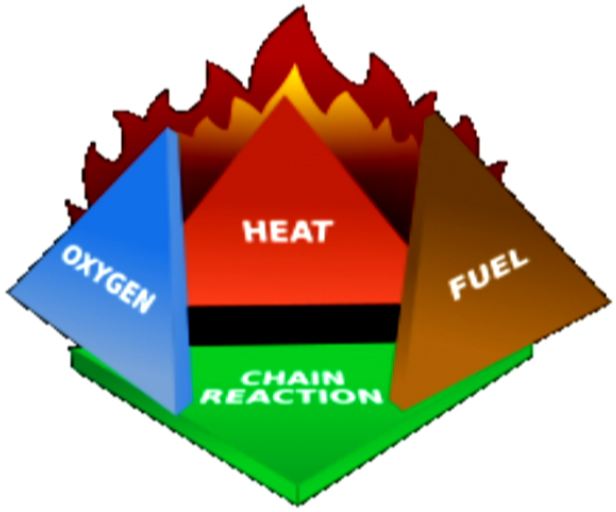
Abstract:

Fire.

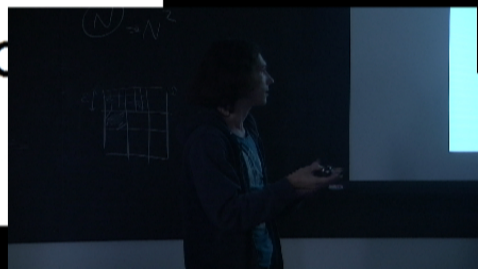
What do we know about it?

Grigory Sizov,
Perimeter Institute.

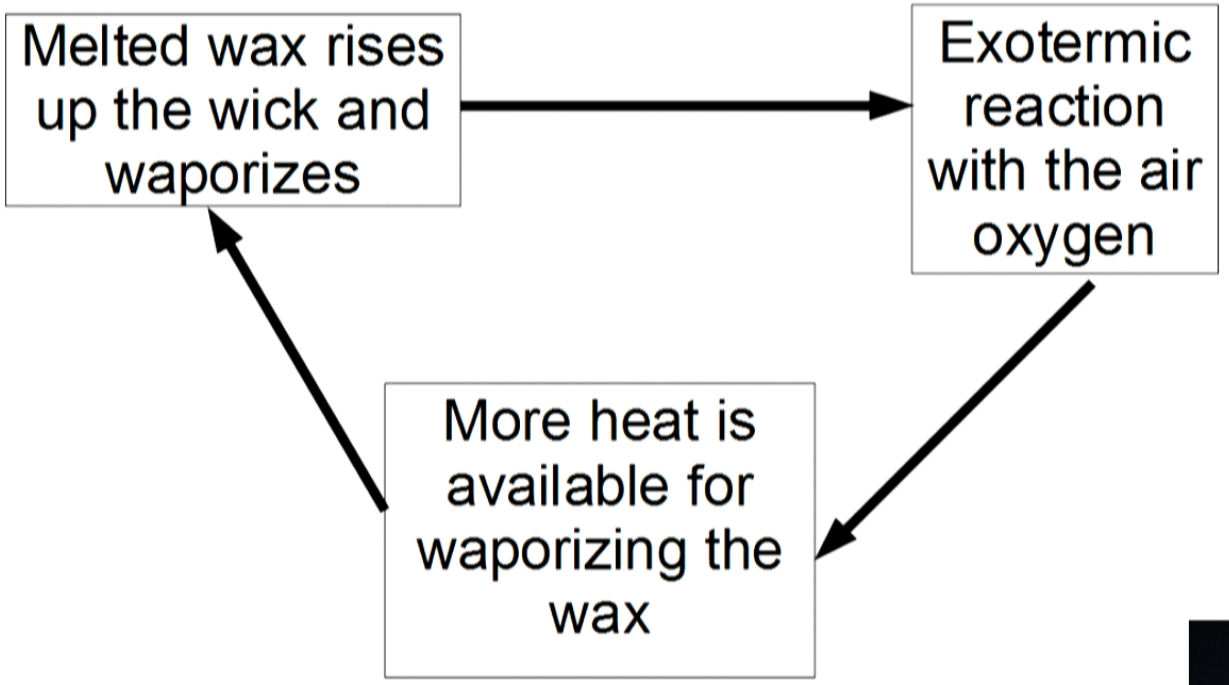
The fire tetrahedron.

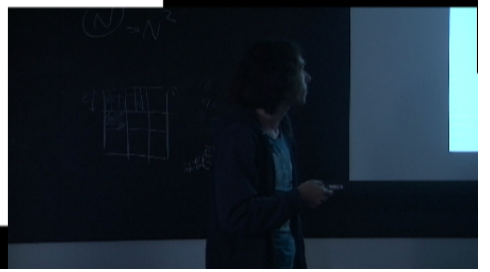


- Process of rapid oxidation
- Releasing heat, light, reaction produc
- Close relatives: rusting, digestion



Example: candle burning.





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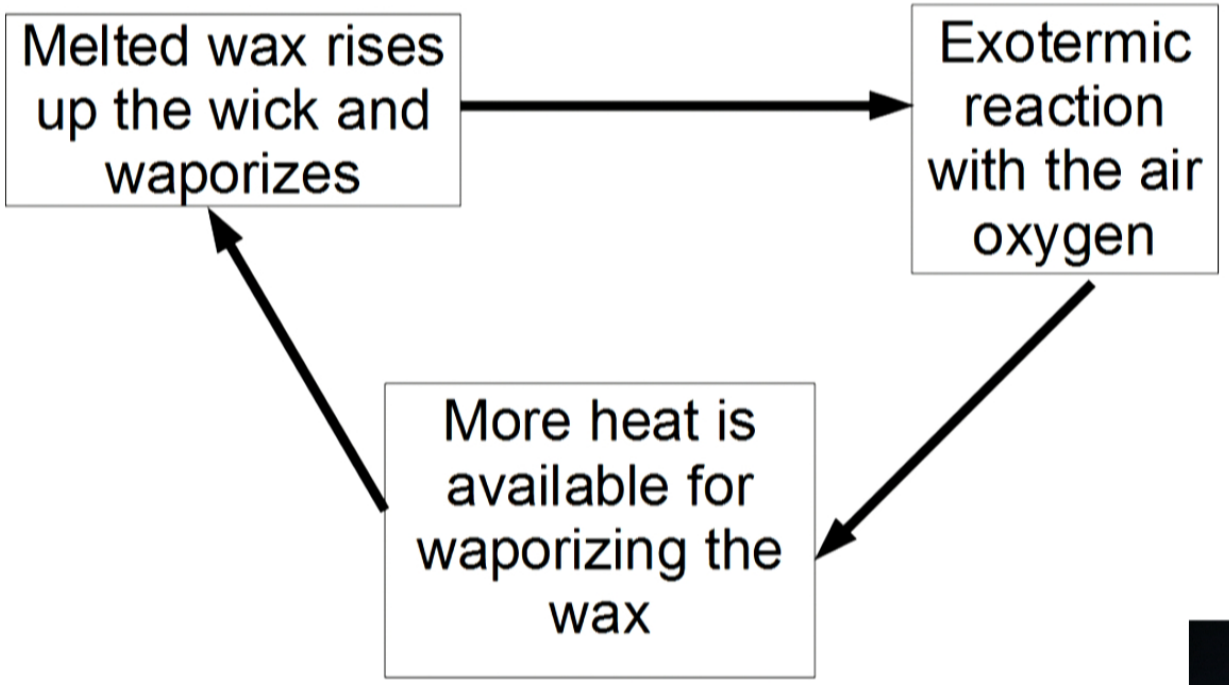

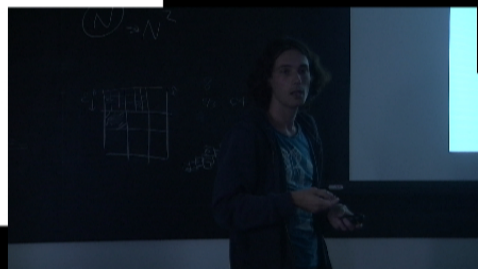

Emission of light and heat

Vaporized fuel moleculas decompose

↓

Incomplete combustion products and free radicals

↓

Flame energy excites the electrons the transient reaction intermediates (CH, C2)

↓

Emission of visible light!

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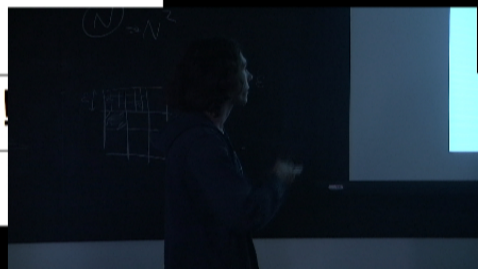
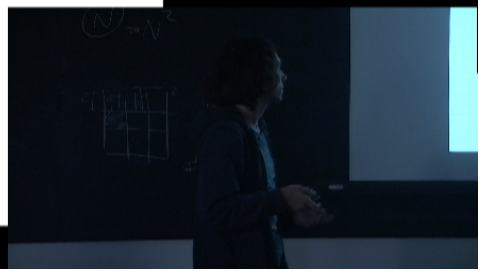


Flame radiation:

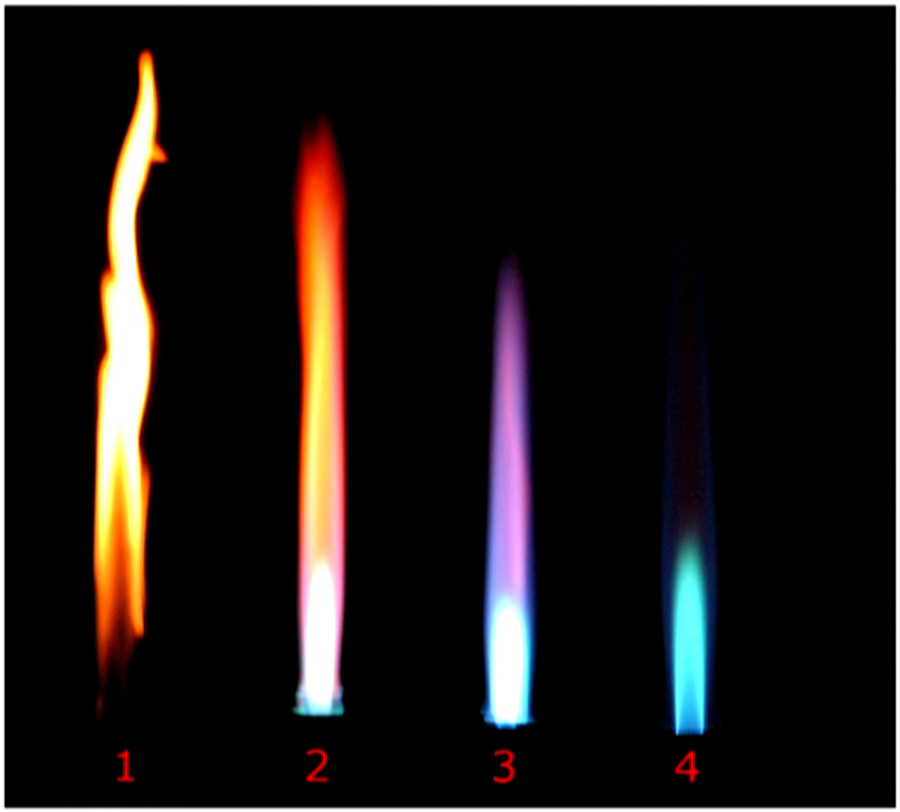
- Blackbody radiation
- Spectral band emission

What determines its color?

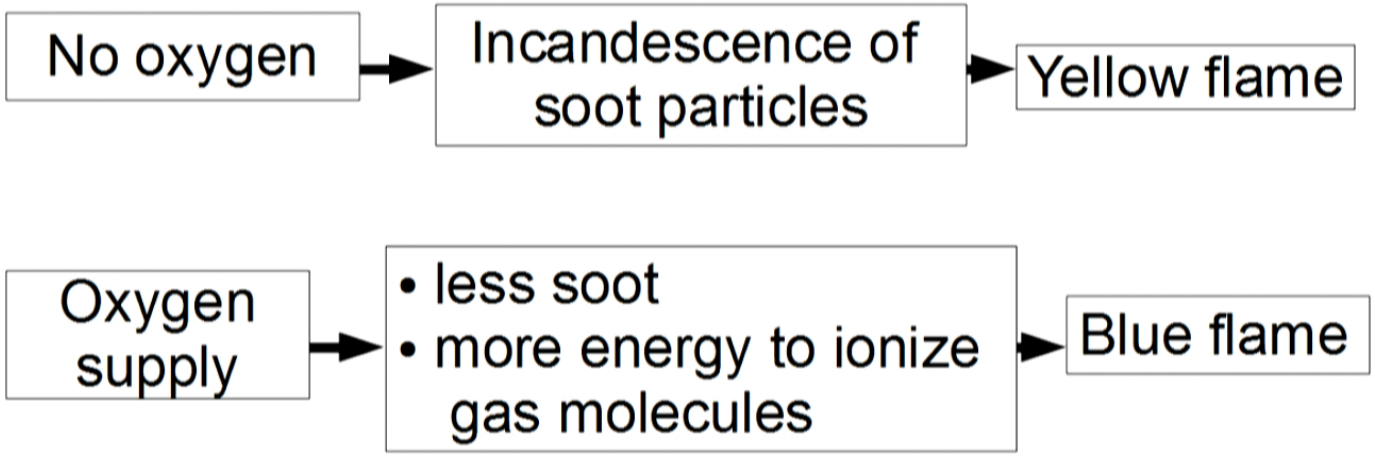
- Temperature
- Oxygen supply
- Fuel matreial

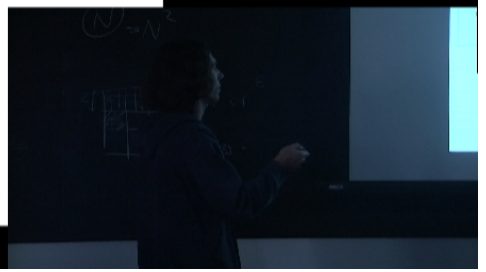


Example:Bunsen burner



How does this work?





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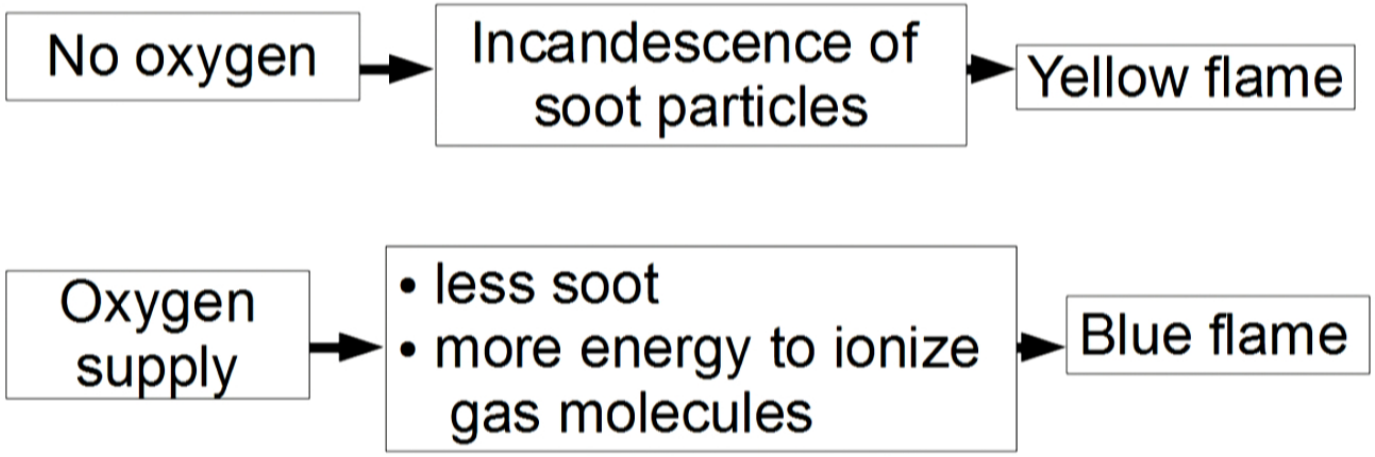
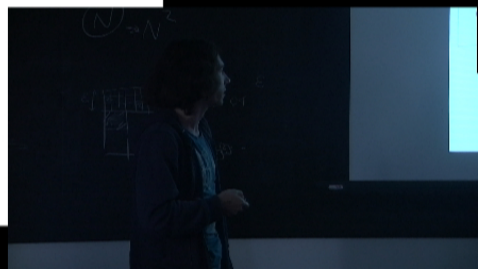
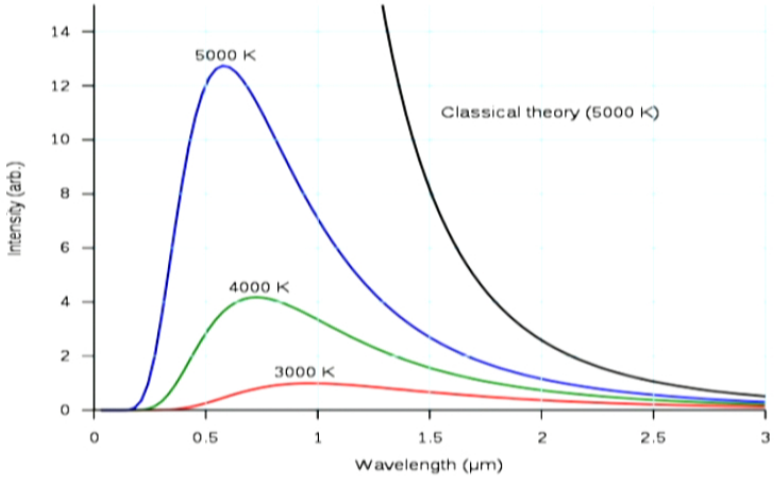




Why does flame color depend on the temperature?

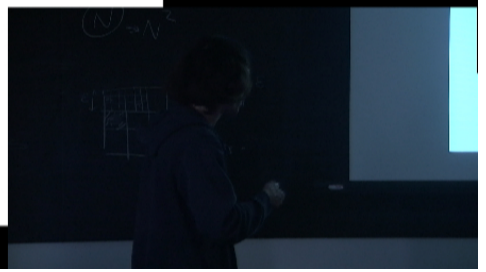
Wien's displacement law:

$$\lambda_{\max} = \frac{b}{T}$$



red orange yellow white

Temperature



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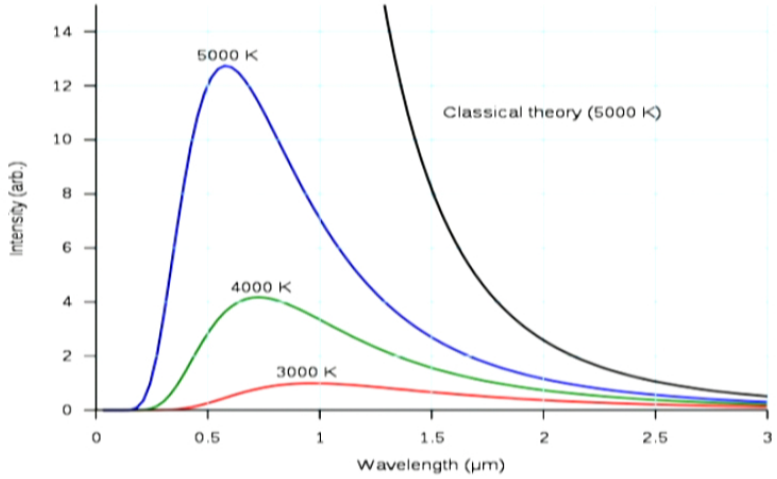

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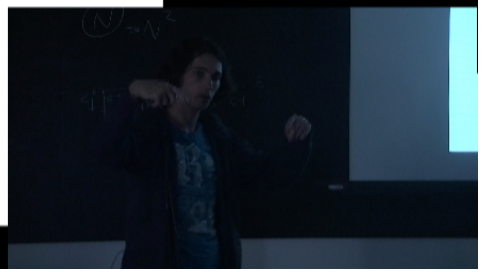
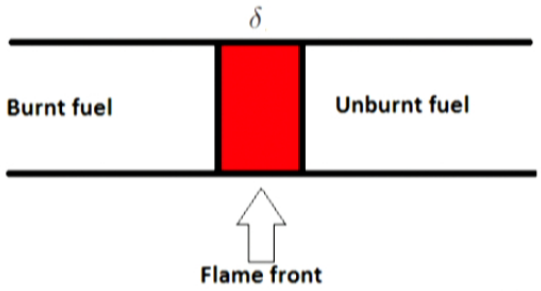


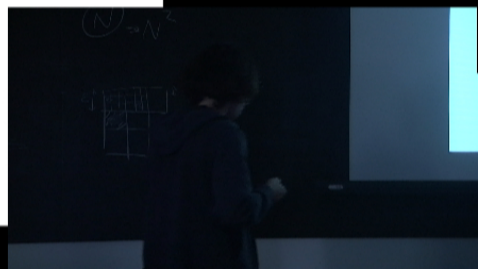
The most simple flame physics.



- Heat diffusion timescale $\tau_d \sim \delta^2 \kappa$
- Burning timescale $\tau_b \propto e^{\frac{\Delta U}{k_B T}}$
- Energy balance $\tau_b = \tau_d$

Flame moves at velocity:

$$S_l = \delta/\tau_b = \sqrt{\kappa/\tau_b} \propto \sqrt{\kappa} \exp\left(-\frac{\Delta U}{2k_B T}\right)$$



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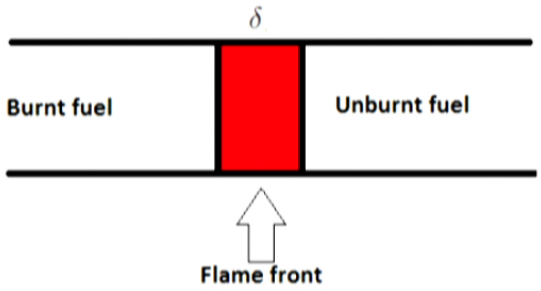

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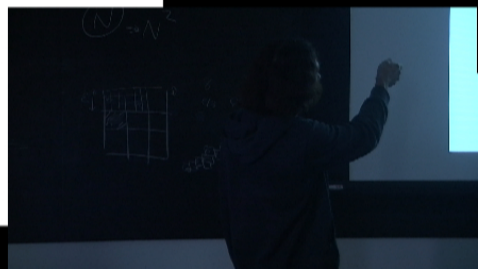
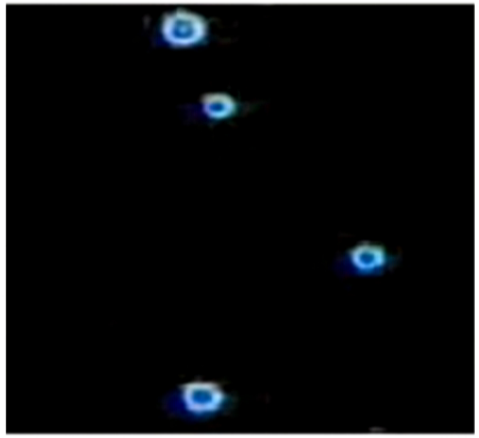


Role of gravity

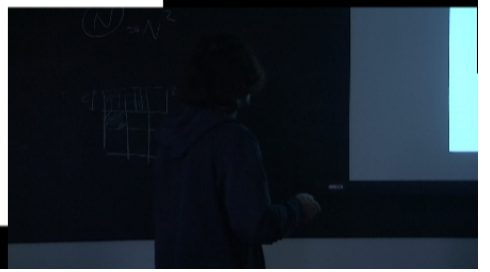
Paul Ronney, 1984, NASA Glenn Research Center's Microgravity Drop Tower



A candle flame in normal gravity.

A candle flame in microgravity.

the weakest flame we have



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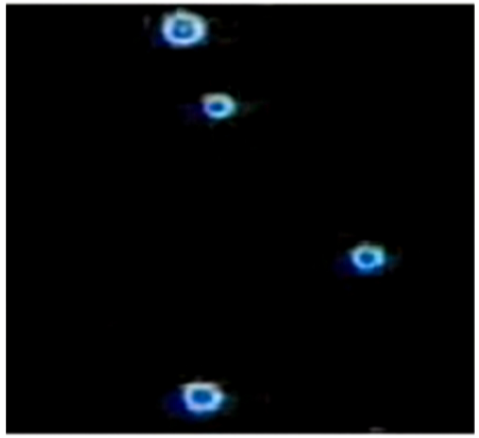

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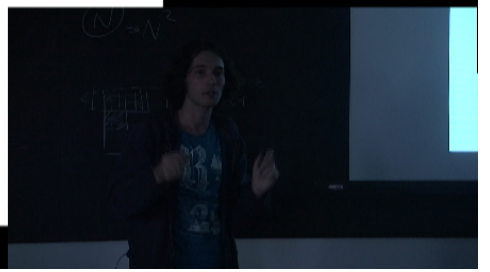

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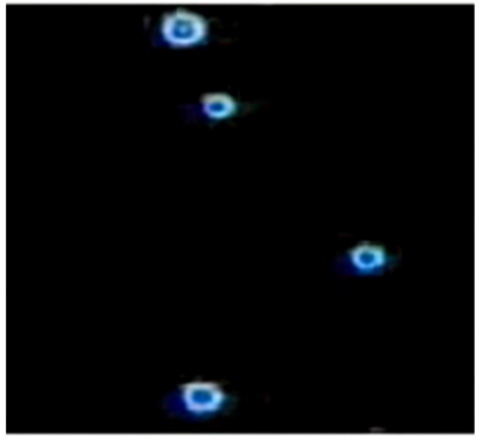

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