Title: Physics in Nature Presentation: The Sun - Not Only Good For Energy

Date: Aug 19, 2011 12:15 PM

URL: http://pirsa.org/11080100

Abstract:

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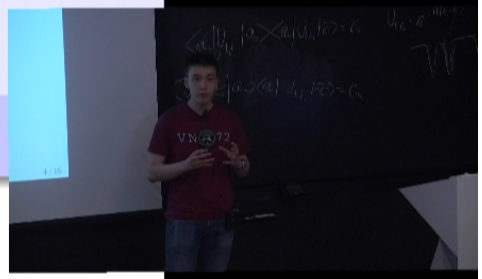

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# The sun

What's the main impact of the sun?

- Common answer: energy
  - heat and electromagnetic radiation
  - essential for the existence of life
- Claim: Not quite true
  - energy can not be destroyed
  - Why do we need new energy?

$\Rightarrow$ Question: What's the role of the sun?

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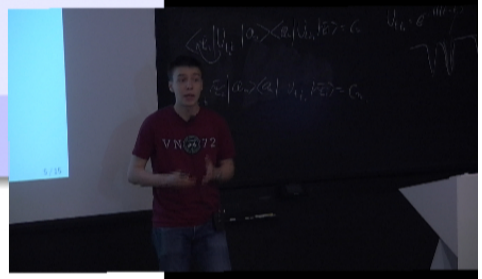

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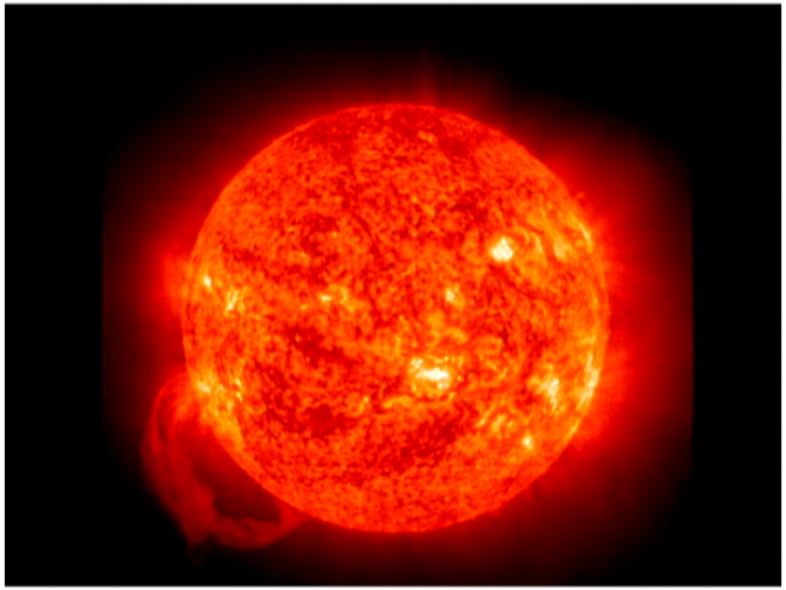
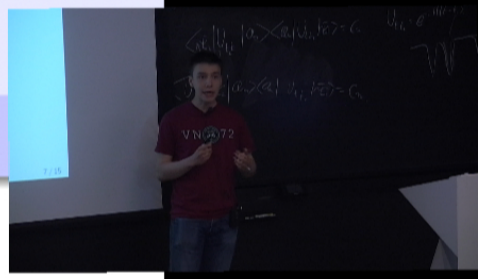


Figure: Photograph courtesy NASA, from National Geographics

# Laws of Thermodynamics

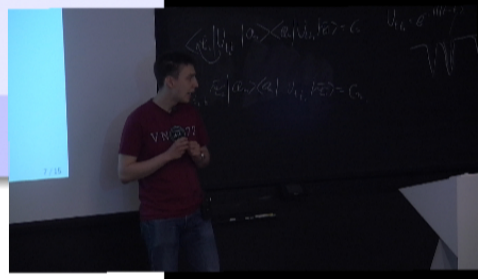


- First law of Thermodynamics

$$\underbrace{dU}_{\text{change of inner energy}} = \underbrace{\delta Q}_{\text{change of heat}} + \underbrace{\delta Q}_{\text{work transfer}}$$

- Second law of Thermodynamics

$$\underbrace{dS}_{\text{change of entropy}} \geq \underbrace{\frac{\delta Q}{T}}_{\text{heat over temperature}}$$



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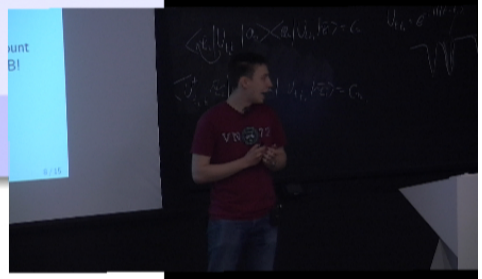
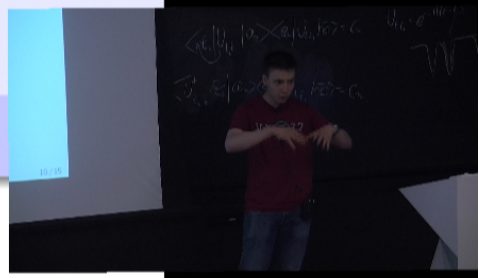


# Entropy

Properties of Entropy:

- can not be destroyed $\Rightarrow$ can not decrease in a closed system
- but: can be created from nothing (irreversible process)
- coupled to heat transport:
  Each heat transfer from system A to system B of heat amount $\Delta Q$ is connected to an entropy transfer of $\frac{\Delta Q}{T}$ from A to B!



# Assumptions

- Systems can be seen as heat reservoirs.
- Heat/entropy transfer only for:
  Earth $\Longrightarrow$ Universe, Earth $\Longrightarrow$ Universe
- Claim:
  backwards transfer is neglactable
- Energy exchange other than by heat is neglectable.
- The inner energy of the earth does not change dramatically:
  $dU_{\text{Earth}} \approx 0$
- The earth does not do work: $\eth W_{\text{Earth}} \approx 0$

$\Rightarrow \eth Q_{\text{Earth}} = 0$

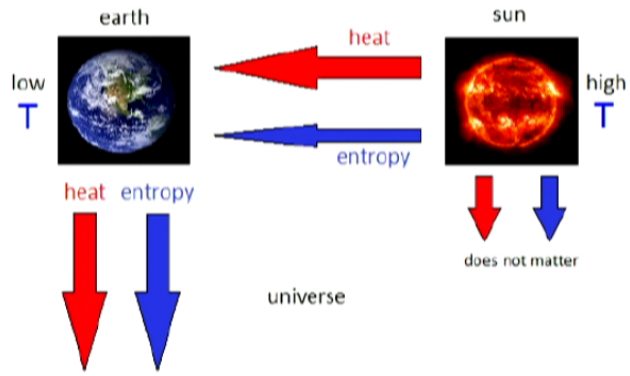
# Heat transfer

- Equilibrium:

$$\Delta Q_{SE} = \Delta Q_{EU}$$

- Total entropy:

$$\Delta S_E = \Delta S_{SE} - \Delta S_{EU}$$




$$\Delta S_{SE} = \frac{\Delta Q_{SE}}{T_S} \ll \frac{\Delta Q_{EU}}{T_E} = \Delta S_{EU}$$

Implication: Entropy $S_E$ can decrease because of $\Delta S_E < 0$.

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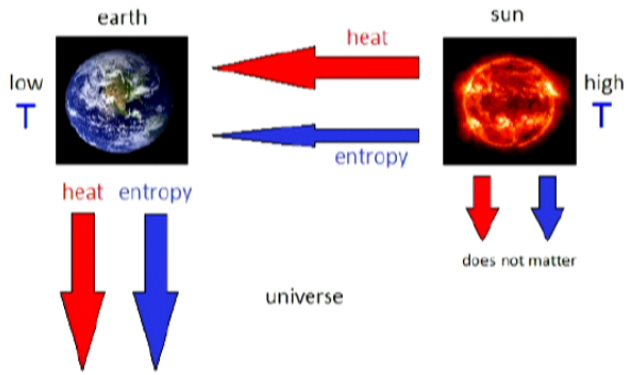


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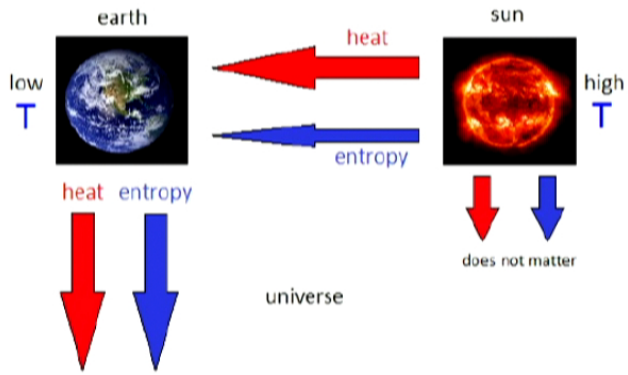


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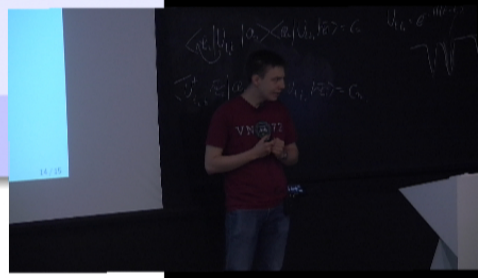


# Take home messages

What's now the role of the sun?

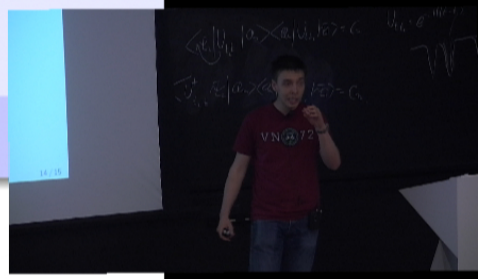
- Yes, the sun provides energy/heat – but in fact only about the same amount we loose because of thermal radiation.
- But of similar importance: The sun provides energy connected to low entropy while the earth releases thermal radiation of high entropy.

And what's about the existence of life?

- Earth is not a closed system.
- The total entropy of the system earth can decrease if it releases entropy.
- Complex structures can come into existence.

And what's about the creationists?

- They have to learn: $\Delta S \geq 0$ holds for closed systems only.



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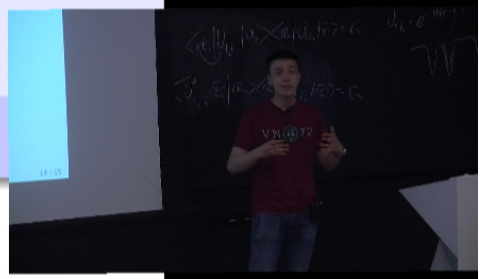

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