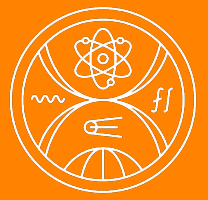
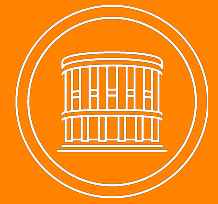


FACULTY OF MATHEMATICS,
PHYSICS AND INFORMATICS
Comenius University
Bratislava

2021 Nobel prize in physics

Juraj Tekel
Department of theoretical physics

4.11.2021, LEAF Academy

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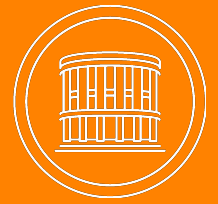
NOBEL

A short quiz



The very first Nobel laureate in physics?

The very first laureate in physics?

Wilhelm Conrad Röntgen (1845 – 1923) in 1901

fig.: wiki

The very first woman laureate?

The very first woman laureate?

Marie Skłodowska Curie (1845 – 1923)

in 1903

fig.: wiki

The very first slovak laureate?

The very first slovak laureate?

So far none.

The very first slovak laureate?

So far none.

Challenge accepted?

2021 Prize

2021 Prize

The Nobel Prize in Physics 2021 was awarded **"for groundbreaking contributions to our understanding of complex systems"** with one half jointly to Syukuro Manabe and Klaus Hasselmann "for the physical modelling of Earth's climate, quantifying variability and reliably predicting global warming" and the other half to Giorgio Parisi "for the discovery of the interplay of disorder and fluctuations in physical systems from atomic to planetary scales."

2021 Prize

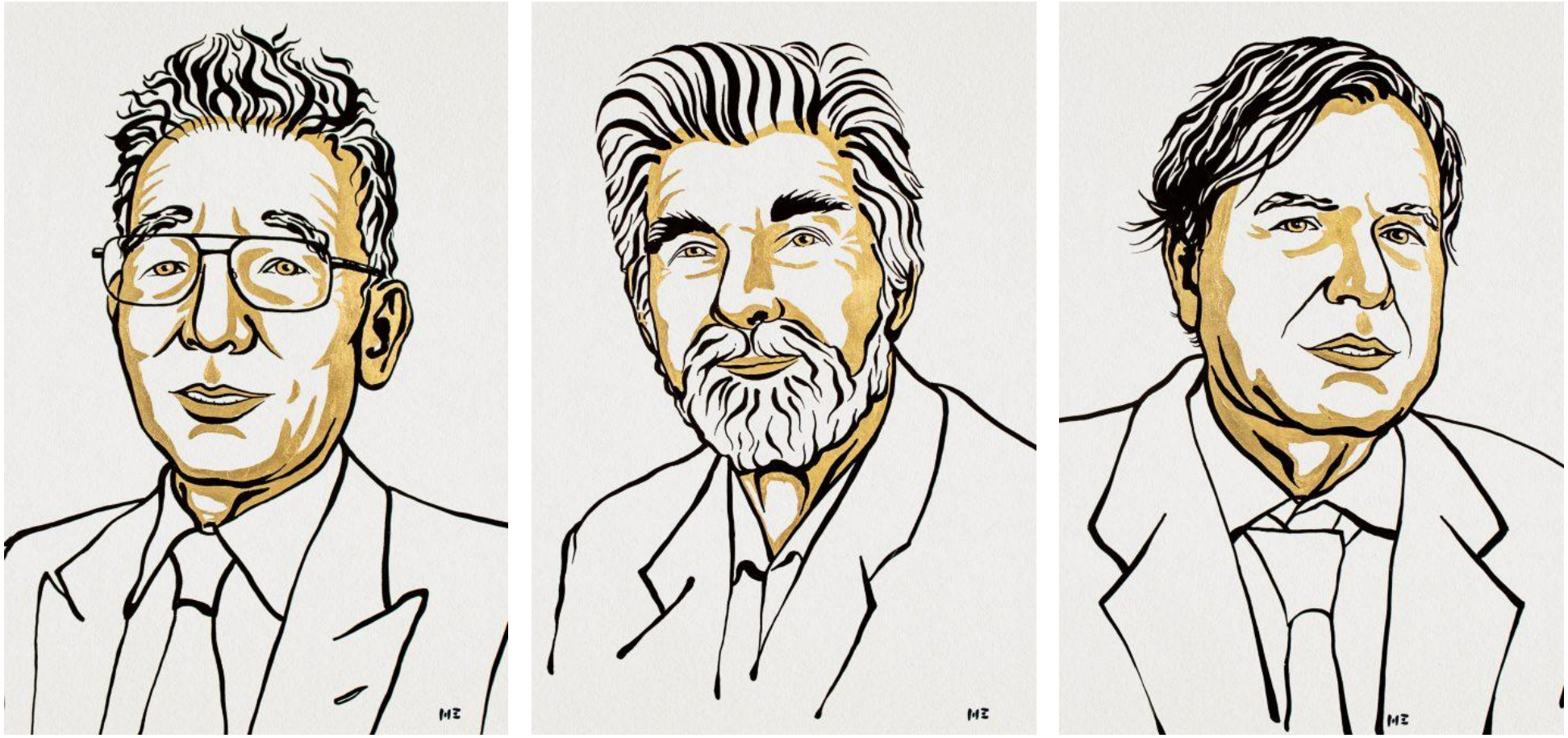


fig.: Ill. Niklas Elmehed © Nobel Prize Outreach

2021 Prize

- Will be remembered as the **“complex systems”** prize.
- Systems with too many degrees of freedom to be described independently:

2021 Prize

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- Systems with too many degrees of freedom to be described independently:
  - coffee in a cup,

2021 Prize

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  - a lot of stuff that goes on in more or less strange materials.

2021 Prize

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- Systems with too many degrees of freedom to be described independently:
  - coffee in a cup,
  - gas in a container,
  - Earth's atmosphere,
  - a lot of stuff that goes on in more or less strange materials.
- Randomness and disorder play a crucial role.

2021 Prize

- Two parts to this year's prize:
  - **Manabe and Hasselmann** - "climate change"

    dealing with a very concrete problem,
  - **Parisi** - "spin glass"

    dealing with general aspects of a large class of problems.
- Both are theoretical, but at very different ends of the spectrum.

Climate change

Climate change

"for the physical modelling of Earth's climate, quantifying variability and reliably predicting global warming"

Climate change - Manabe

- The greenhouse effect is essential for life on Earth.
- Most important greenhouse gasses are CO_2 and water.
- Warmer air can hold more water, which leads to a runaway effect.

Climate change - Manabe

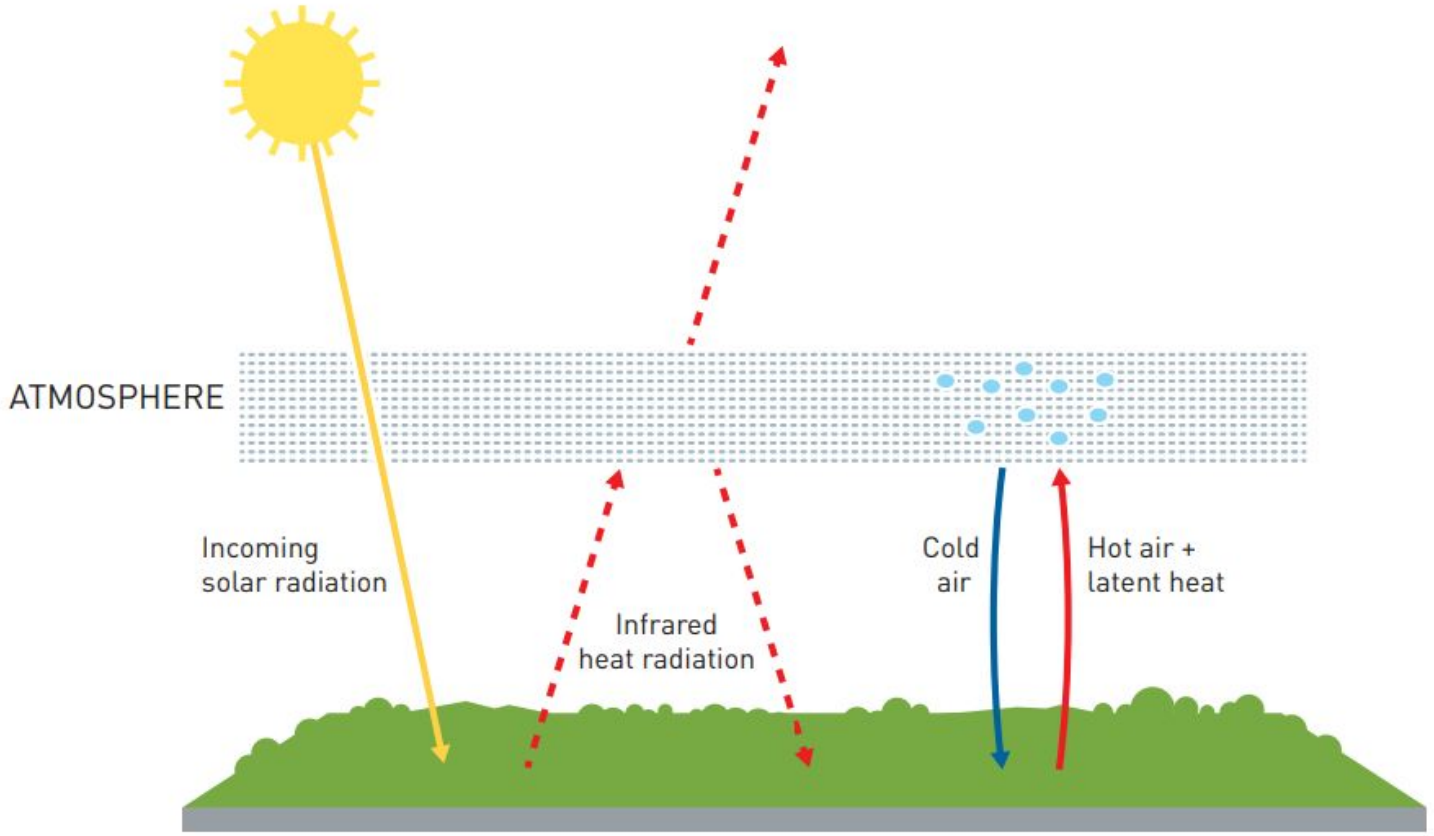


fig.: Johan Jarnestad/The Royal Swedish Academy of Sciences

Climate change - Manabe

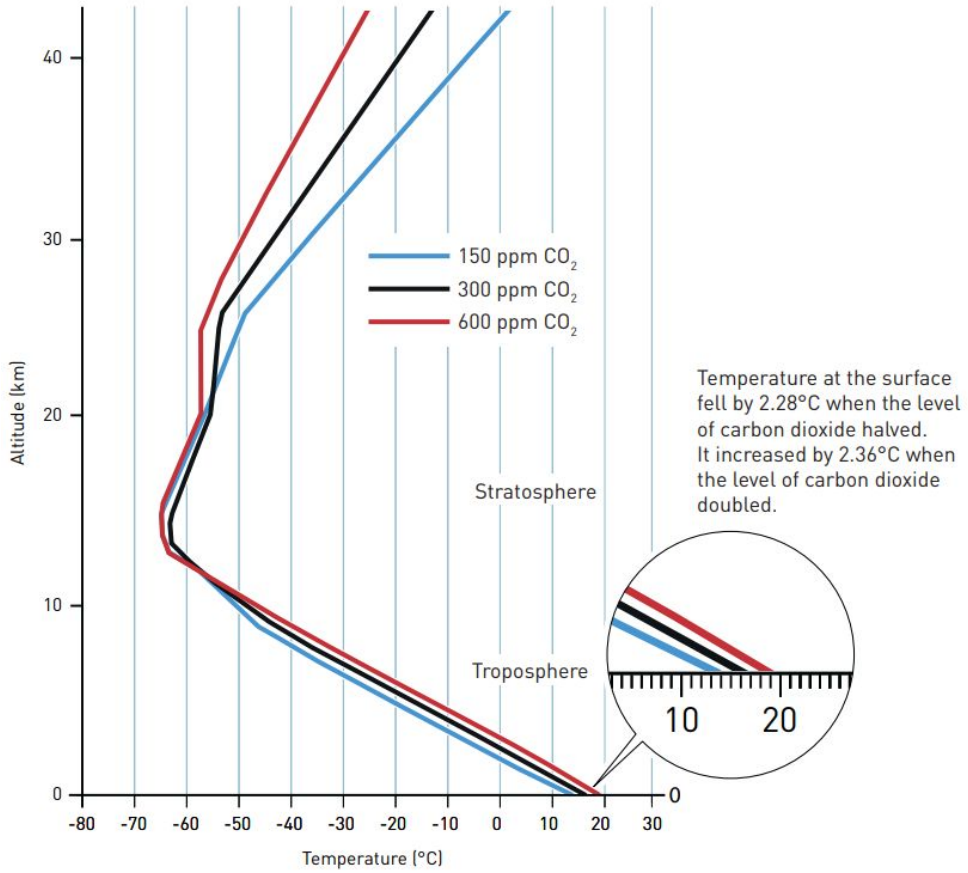


fig.: Manabe, Wetherald (1967)

Climate change - Hasselmann

- Our planet has vast shifts in its weather because solar radiation is so unevenly distributed, both geographically and over time.
- How can we produce reliable climate models for several decades or hundreds of years into the future, despite weather being a classic example of a chaotic system?

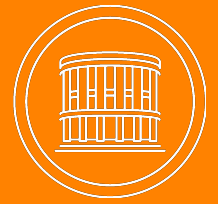
Climate change - Hasselmann

- Hasselmann created a stochastic climate model, with similarities to Brownian motion.
- Hasselman cleared the way to further studies of climate change, which have demonstrated of human impact on the climate.

Climate change

- Manabe and Hasselmann have provided a solid physical foundation for our knowledge of Earth's climate, the way it changes and to the conclusion that these changes are consequence of our activities.

Spin glass



Spin glass

"for the discovery of the interplay of disorder and fluctuations in physical systems from atomic to planetary scales"

Spin glass

- Description of macroscopic objects in terms of their fundamental constituents is doomed to fail (very soon).
- At macroscopic level, all we need is behavior of very few quantities, which is described by thermodynamics.
- Laws of thermodynamics can be derived from (fundamental) microscopic laws by statistical physics.
- Our ignorance about (to) the microscopic behavior is modeled by probilities and averages.

Spin glass

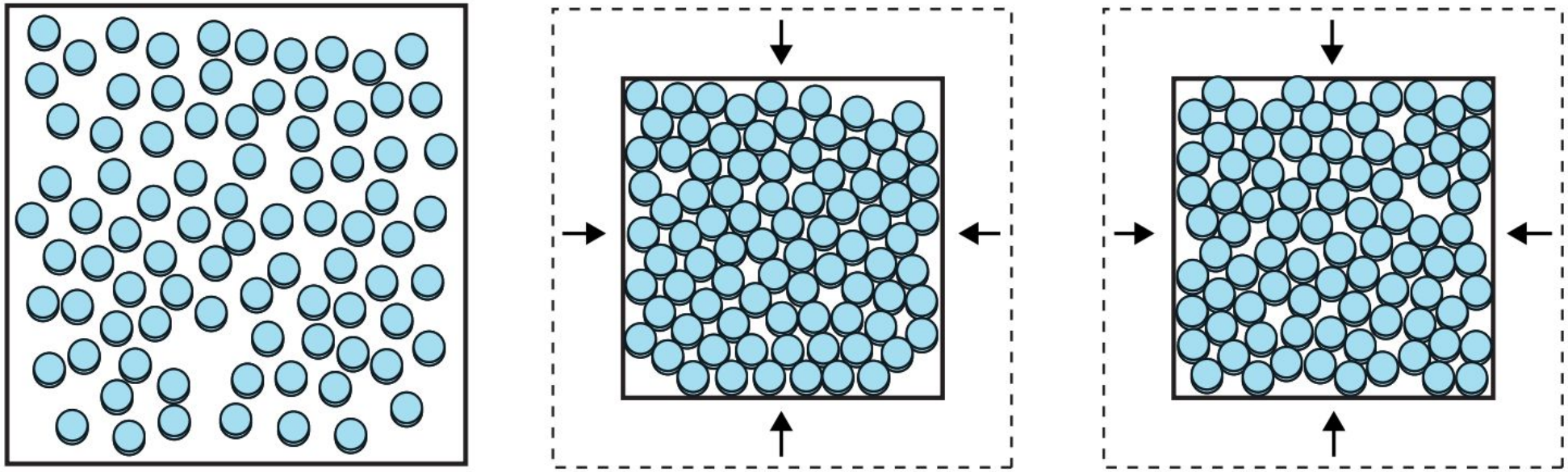
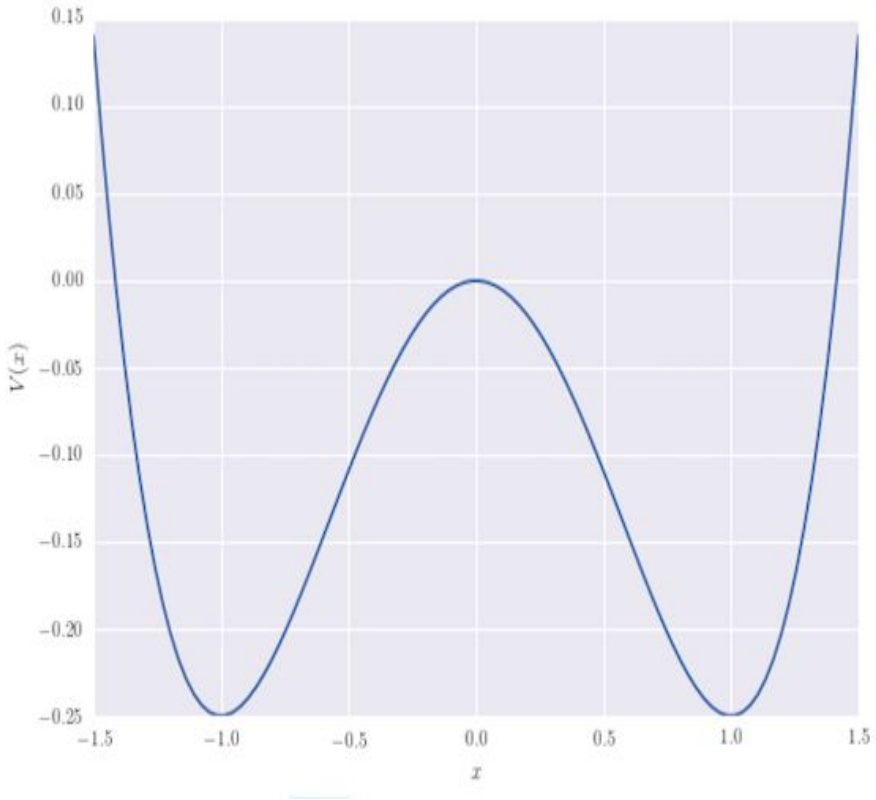


fig.: Johan Jarnestad/The Royal Swedish Academy of Sciences

Spin glass



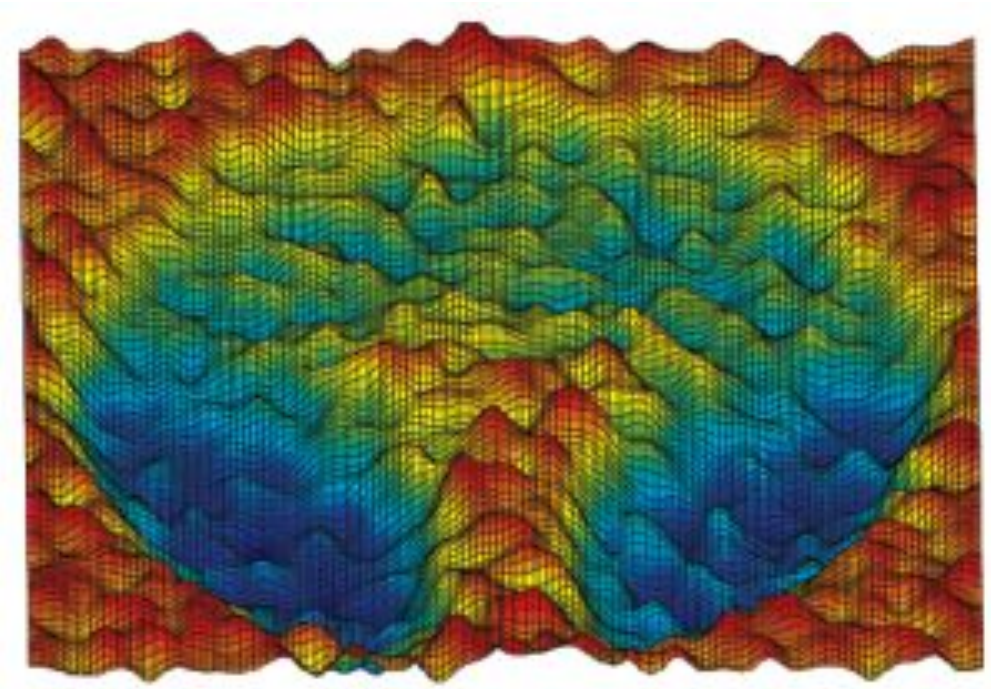
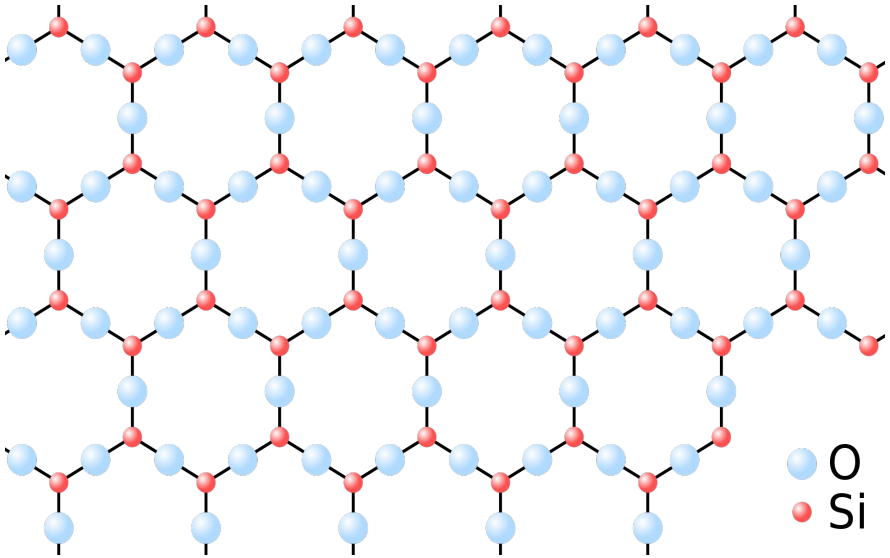


fig.: https://scipython.com/blog/a-quartic-oscillator/

http://www.ipam.ucla.edu/programs/long-programs/complex-high-dimensional-energy-landscapes/

Spin glass



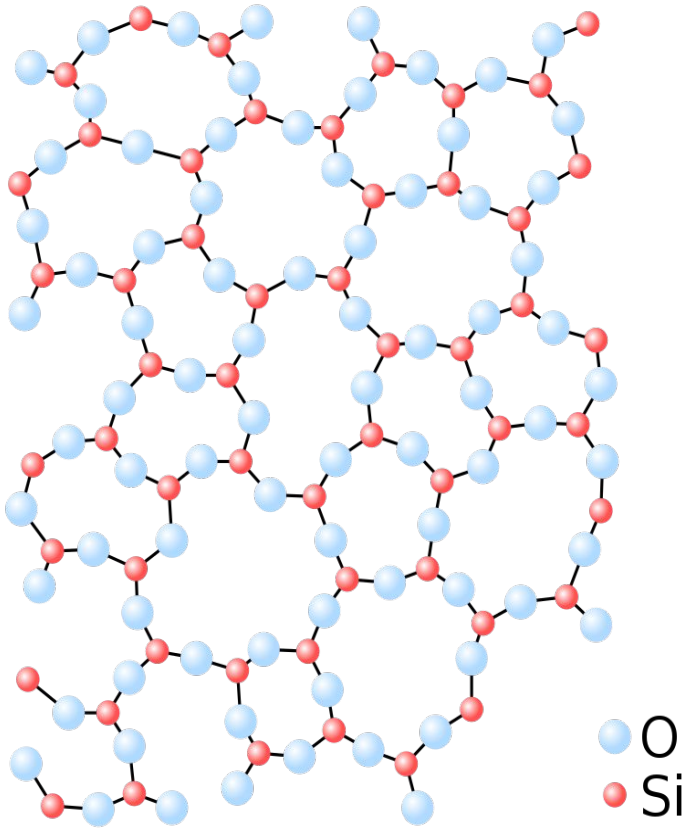


fig.: wiki

Spin glass

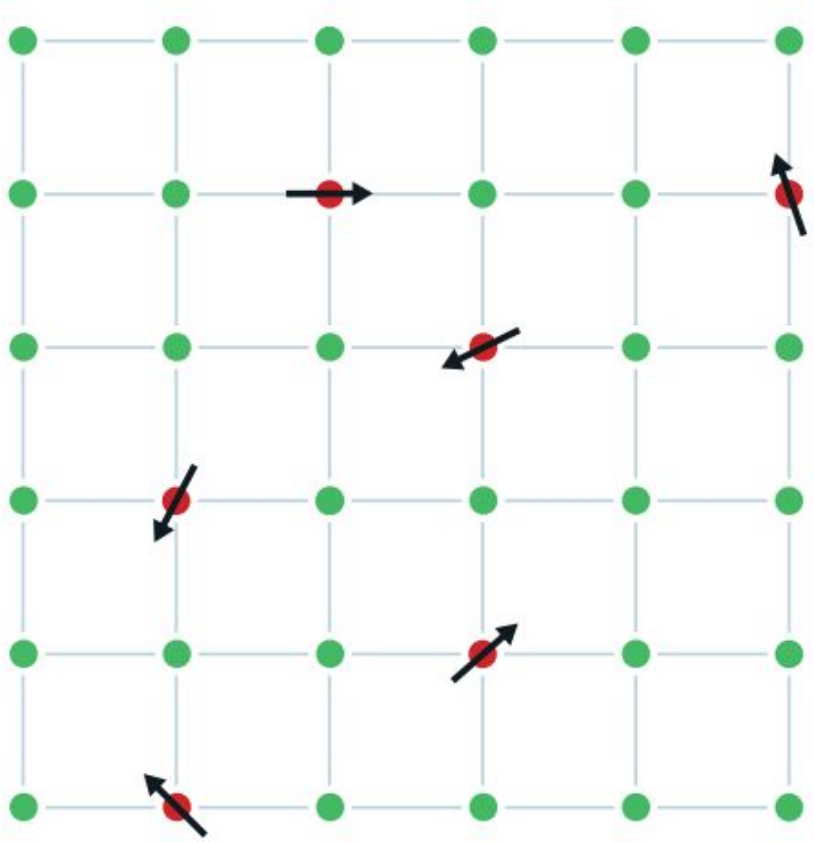


fig.: Johan Jarnestad/The Royal Swedish Academy of Sciences

Spin glass

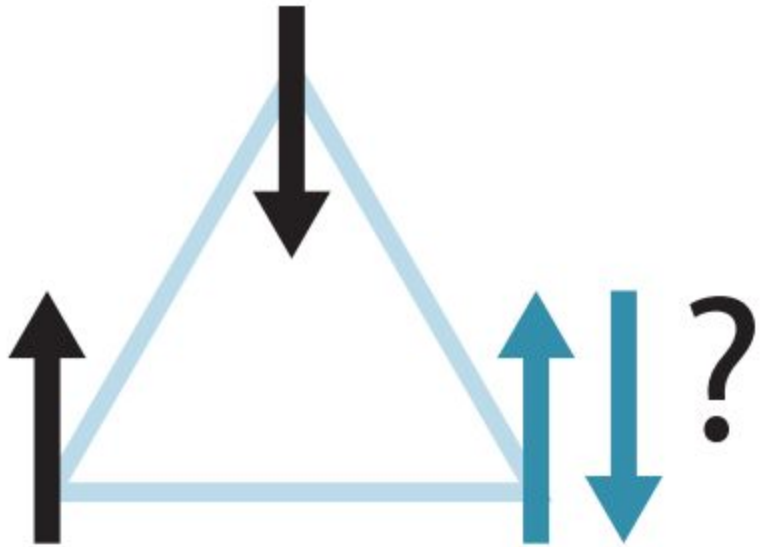


fig.: Johan Jarnestad/The Royal Swedish Academy of Sciences

To conclude

Conclusion

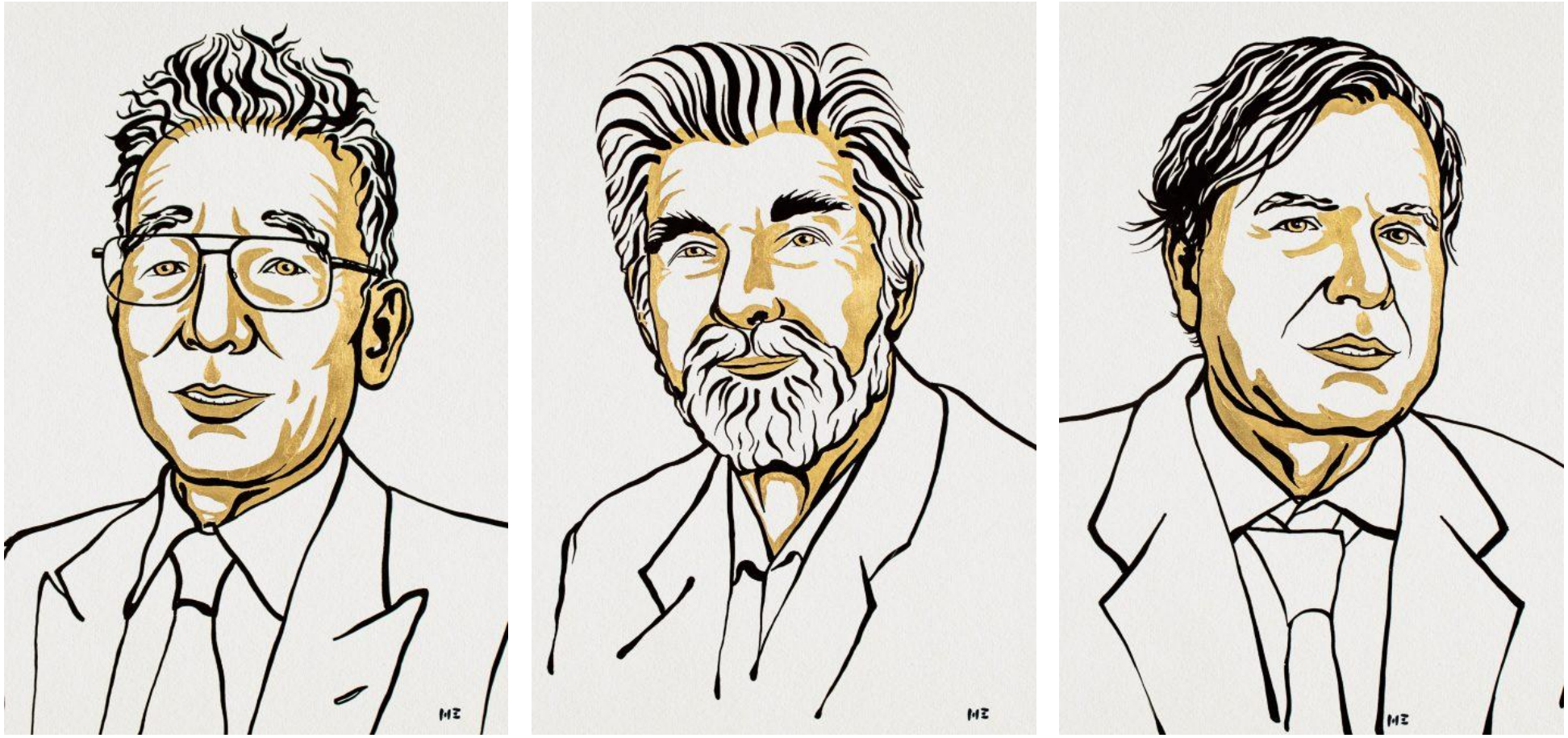


fig.: Ill. Niklas Elmehed © Nobel Prize Outreach

Conclusion

- 2021 Nobel prize in physics was awarded for study of **complex systems**.
- Recognition of work in climate modeling and in statistical physics.
- For showing that even very complicated and difficult to grasp and control systems can be systematically studied, described and understood.

Thanks for your attention!