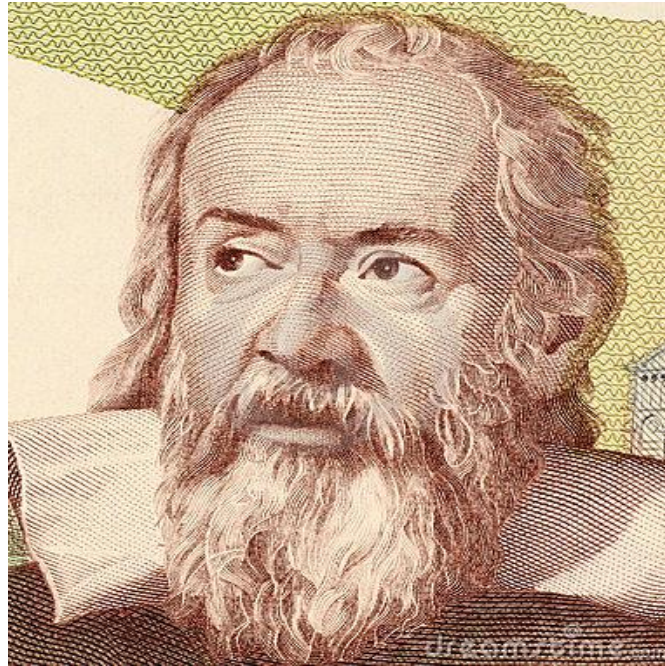


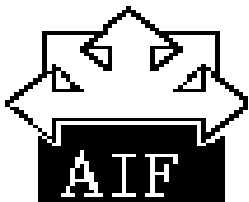
ISSHPSE
Lille Summer School 2015
Poster Session

Galilei remarks "Concerning an investigation on dice", as a tool to understand the thermodynamic concepts.



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History of science in teaching

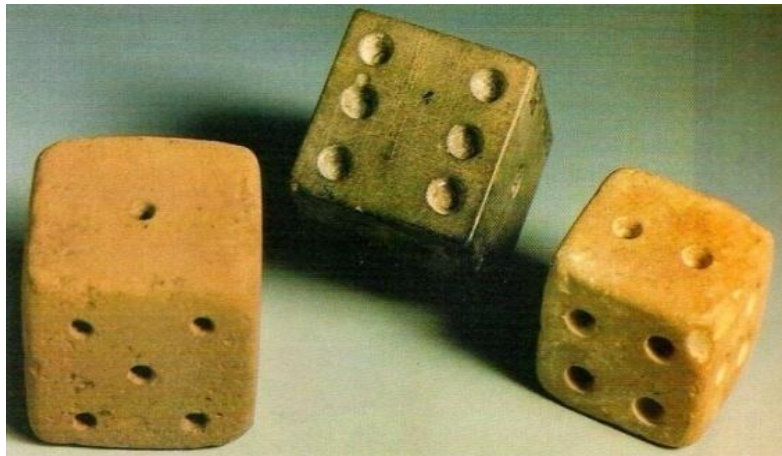
To show

- The roots of the present culture
- How the ancients philosophize
- How the humanistic and scientific culture create knowledge



Zara game

Quoted by Dante and Galileo



Three dice are cast and the player guesses their sum from 3 to 18

The Divine Comedy

Purgatorio: Canto VI



*Whene'er is broken up the game of Zara,
He who has lost remains behind despondent,
The throws repeating, and in sadness learns;
The people with the other all depart;
One goes in front, and one behind doth pluck
him,
And at his side one brings himself to mind;
He pauses not, and this and that one hears;
They crowd no more to whom his hand he
stretches,
And from the throng he thus defends himself.
Even such was I in that dense multitude,¹⁰
Turning to them this way and that my face,
And, promising, I freed myself therefrom.*

Dante compares himself with a Zara player

A Florence gentleman asked Galilei why in the Zara game is the sum of 10 or 11 more frequent than the sum of 9 or 12?



The Galilei remarks :

In the dice game, certain numbers are more frequently cast than others ... e.g., the number of partitions of 9 or 12 in exactly 3 parts is equal to that obtained for 10 or 11, but through long observation, a dice-player learns the advantage of casting a sum 10 or 11 over 9 or 12.

The following table shows the Galilei demonstration

The table shows the different partitions obtainable for the 9 and the 10 into exactly three parts; the number of ways each partition is realized in a throw is written next to each of them, and the sum of these numbers is at the bottom.

The number of partitions of 10 or of 9 into exactly three parts is 6.

10	(m)	9	(m)
631	(6)	621	(6)
622	(3)	531	(6)
541	(6)	522	(3)
532	(6)	441	(3)
442	(3)	432	(6)
433	(3)	333	(1)
27 times		25 times	

216 = all the possible throws

$$25/216 < 27/216$$

The probability to obtain the 9 is less than the probability of the 10.

A triplet of dice can sum to 10 in each of **27** different throws

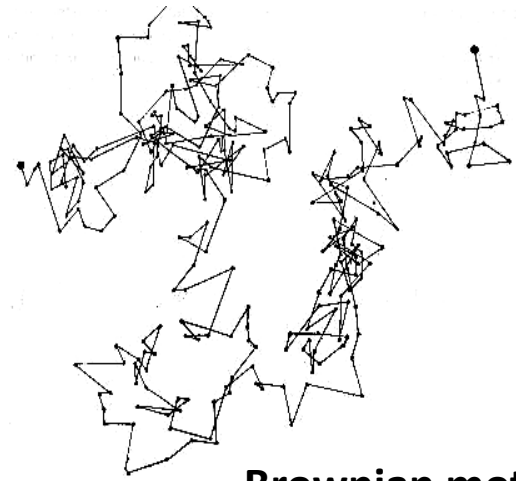
A triplet of dice can sum to 9 in each of **25** different throws

At beginning of the XX century the probability theory became the language of thermodynamics

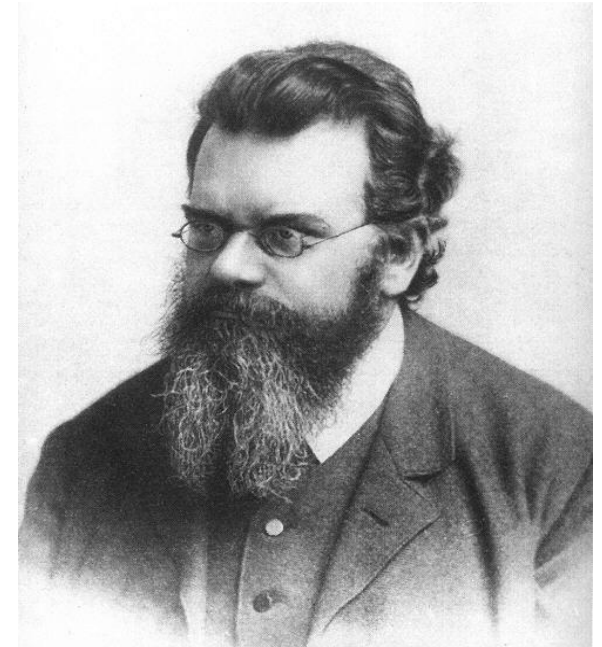
In a thermodynamic system:

- a **microstate** is a specific microscopic configuration: like a theoretical "absolutely *instantaneous* photo" of the location and momentum of *each* molecule and atom.
- the **macrostate** refers to the system macroscopic properties, such as temperature and pressure
- The **thermodynamic probability** W is equal to the number of microstates specified by a macrostate.
- The **entropy** S of a perfect gas is given by the **Planck-Boltzmann relation**

$$S = k \ln W,$$



Brownian motion



Ludwig Boltzmann 1844-1906

*An **analogy** between the numbers resulting from the throw of three dice and the thermodynamic concepts*

The number 9 is obtained in 25 different ways

9 = macrostate

each of the 25 triples = microstate

25 = thermodynamical probability

25/216 = mathematical probability

*

216 = the sum of all the possible throws



Bibliography

1. *Sopra le scoperte dei dadi*, Galileo Galilei, *Opere*, Firenze, Barbera , **8** (1898) p.p.591-594
2. I. Prigogine, *Le leggi del caos*, Laterza (1993)
3. Charles P. Snow, *Le due culture*, Marsilio (2005)