

**Father and Son at the Pole or: What's the Earth doing ?
A sketch on Foucault's Pendulum and its interpretation**

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From the itinerant lecturers of the 18th century to popularizing physics in the 21st century –
exploring the relationship between learning and entertainment

Proceedings of a conference held in Pognana sul Lario / Italy, June 1-6, 2003.

Eds.: Jürgen Teichmann, Arthur Stinner, Falk Rieß,

Munich, Winnipeg, Oldenburg 2004

www.deutsches-museum.de, www.hsse.uwinnipeg.ca, www.uni-oldenburg.de/histodid



Deutsches Museum

Abstract:

The ambiguities of the usual interpretation of Foucault's pendulum, and how to give right to Galileo in a modern way, are evidenced in a small sketch putting on stage visitors at the museum.

Introduction

Foucault's Pendulum has been immediately interpreted in 1851, and yet often nowadays in public demonstrations, as “the” internal proof — for so long searched — of an *absolute* daily rotation of the Earth. However, from the abandonment of Newton's absolute space, motion can only be relative. Thus, Ptolemy and Copernicus' points of view might appear as completely symmetrical in a purely kinematic description. Only a dynamical interpretation, — leading to the evidence of the non-galilean character of the Earth system of reference — can finally give right retrospectively to Galileo against his judges. However, this is more subtle and difficult to explain to visitors in a museum than simply saying: “it proves that the Earth is rotating”. The following sketch, putting on stage the underlying millenary debate between geocentrism, heliocentrism and finally a-centrism, is an attempt towards such a public demonstration.

Personae dramatis

The father, referred as “Father”

The son, referred as “Son”

The Museum's lecturer, referred as “Museum”

A Foucault pendulum, referred as “The Pendulum”.

Father and Son are watching the Foucault pendulum — “The Pendulum” — in the Museum. Father is around fifty and is already greying around, Son looks very young, he is slender and taller than Father. They are holding hands.

Son:

Dad, what's the matter?

Father:

It's a Foucault pendulum, it proves the rotation of the Earth.

Son:

But this, I know definitely, I don't need the demonstration!

Father:

However, it's a fine ideal!

The Museum's lecturer enters the showroom.

Museum:

(looking important and directing his finger towards the son)

Oh, Son, how right you are, you don't know how deeply right! but listen to me now. As Father said, as your teacher said, and Mother too — the three main proofs! — the Pendulum is intended to prove the Earth's rotation. However, things are a bit more complicated here at Pognana since we do not lie on the Earth's axis. But they will become more obvious at the Pole. Thus, Father and Bambino, we are going to leave for the North Pole!

Father:

Is it really worth going?

Museum:

Yes!

Son:

OK! I like that.

Museum:

Let us take off for the Pole!

Father and Son leave the room, waving their arms and soon come again from another door.

Museum:

(wearing a red woollen hat)

Brrr!

(throwing warm clothes to the protagonists)

Son! Don't catch a cold, take this pullover, and you too, Father, take this warm scarf. And put on your gloves.

(Father and Son now are watching the Pendulum swinging just at the Pole)

Here we are! Bambino, look at this star, just above the horizon, it's Aldebaran, star among the stars! Do you see it ? The Pendulum is swinging just towards this star. Now, let us wait one hour, two hours, one day, three days...

Father and Son:

Brrr!

Museum:

Please, *only* look at the stars, forget the Earth. Do you see? During its oscillation, the Pendulum is continuously pointing towards the *same* star!

Son:

OK! I can see, but don't bother, one hour is enough for me to realize that!

Museum:

Now, do you understand? the Pendulum's oscillation is rigidly bound to the Sky. The Pendulum *is* the Sky! Is it clear?

Son:

Yes, quite clear.

Father:

Hum, hum..., but what more?

Museum:

Now, Son, *only* look at the ground, forget the sky. What do you see ? Let us wait one more hour.

Son:

Oh! the swinging direction is slowly rotating clockwise!

Museum:

Yes. Exactly 15° per hour, just one turn in one day!

(holding a large hemispherical piece of blue cardboard full of many small holes and looking through it before the window)

Now, look at this, put your eye through. What is it?

Son:

Oh! It is a sky! Very beautiful, all stars!

Father:

Oh, I never saw such a planetarium!

The poem "The Sky" by Charles Baudelaire (Baudelaire, 1862) — "Le Couvercle" (the lid) in French — appears on the screen, a verse is underlined.

Museum:

Listen to Baudelaire:

"The Sky: the black lid of the mighty pot
Where the vast human generations boil!"

or, in French:

"Le Ciel! Couvercle noir de la grande marmite
Où bout l'imperceptible et vaste Humanité."

(He puts the lid successively over Father and Son's head.)

Our cardboard sky is the lid, *you* are the human generations!

Museum:

(He fixes an arrow along a diameter of the "Sky")

Now, look at this arrow. It symbolizes the direction of the star towards which the Pendulum is swinging. Remember, you agreed that the direction of the oscillation is *bound* to the Sky.

(Now rotating the lid above the ground.)

And you saw this direction rotating clockwise above the ground, isn't it? What conclusion?

Father:

What conclusion? Hum... only one: the Sky is rotating about the Earth's polar axis in one day!

Museum:

You cannot escape this conclusion.

Son:

But I know that it is the Earth which is rotating, *not* the sky! It's an illusion!

Museum:

Right! Just like on the merry-go-round. But, finally, *nothing* has been proved.

(Cardinal Robert Bellarmine appears on a transparency and on a poster.)

Museum:

You are just in the situation of Cardinal Bellarmine, implicitly writing to Galileo by the way of Father Foscarini in 1615, Robert Bellarmine who had been a party in sentencing Giordano Bruno to stake in 1600.

(He points at "Galileo" — a man in the audience — while reading an extract of the letter appearing on the screen.)

“You, Father Foscarini, and *you* Signor Galileo would act cautiously by speaking hypothetically, not affirmatively... When Virgile says: “the shore now moves away from us”, I answer that, even if it may seem clear to a traveler that the shore is moving away from the boat, *however* he knows that it is an illusion and he is able to correct, because he understands clearly that it is the boat which is moving.”

Son:

But, isn't it the sky which is *our* landscape and the Earth *our* boat in which all of us, as you said, are boiling?

A new Bellarmine appears on a transparency, with a halo around his head.

Museum:

(explaining and pointing at Bellarmine)

Now, I am Bellarmine... supposed to be in Paradize since he is a saint!

The Museum's lecturer is Bellarmine yet for two lines.

Museum-Bellarmino:

Oh, Bambino, please, repeat just what you said.

Son:

Isn't it the sky which is *our* landscape and the Earth *our* boat?

Museum-Bellarmino:

Oh! he throws me quite into confusion. Oh! would I have involuntarily written just the contrary of what I meant? Oh! terrifying situation for a saint! Almost four centuries of confusion! four centuries! Oh, why didn't I follow Augustine, in his great wisdom:

“We should not rashly support an opinion on an obscure subject, in order not to have to detest later — for the sake of our own errors — the truth which will be revealed to us.”

Exit Bellarmino.

Museum:

Now, Father and Son, which conclusion? Sky is rotating? Earth is rotating?

Son:

Dad, this guy is literally taking us for a ride!

(Citations from Newton and from Plutarque appear on the screen.)

Museum:

Both are right! From the abandonment of Newton's absolute space,

“The absolute space, not related to external things, remains always similar and motionless”,

the absolute space is now obsolete, thus, no absolute reference grid in the Universe to plot your position, no location! all is moving, change is the rule! And this is a very old idea, see Plutarch:

“Neither the Earth nor the Sea
Have ever got either center or umbilic
If ever there was one, only the gods
And not the men know where it is...”

(Portraits of Poincaré and Einstein appear on the screen and on posters.)

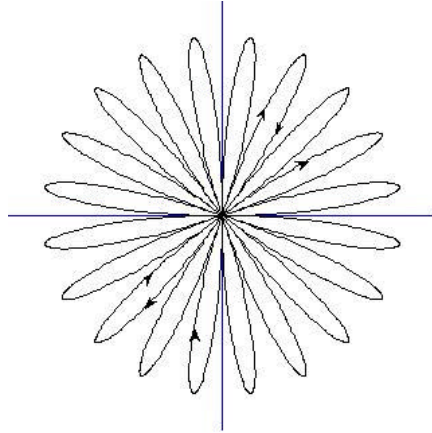
Poincaré also strongly underlined that point just a century ago, and further Einstein on its way towards the general equivalence of all systems of reference.

Father:

But then, what about Galileo and its judges? Was Galileo right, and Copernicus and all others? Do the Pendulum prove more than a *relative* rotation? Otherwise, no need of such a sophisticated device, only look at the Sun during the day and at the stars during the night!

Museum:

Yes, it proves more.



(On the screen, a picture is shown, illustrating the shape of the Pendulum's path on the ground. Note that such a shape corresponds to the following initial conditions: a brief impulse is suddenly applied to the Pendulum initially at rest; other initial conditions lead to other beautiful, but different, shapes. The angular velocity of the Earth has been considerably increased for visualization: one complete rotation for 10 pendulum oscillations.)

Yes, more. Look at those trajectories of the Pendulum's tip on the ground. Not straight, beautiful like marguerite petals, beautiful but *complicated*, aren't they?

Father and Son:

Sure! beautiful and complicated!

Museum:

Now, Father and Son, imagine you are very clever Inuits, and provided with instruments of unlimited precision. Analysing the shape of those curves, you are able to deduce the underlying forces responsible for the whole motion, you get three ones: the gravity, the centrifugal force and the as said Coriolis force, this last one responsible for the observed deviation. And since you are very clever, immediately you understand that everything becomes simple, marvellously simple in a system of reference bound to the stars, the "stars" or "copernican" system: then, one and only one force — gravity — and a fixed straight trajectory.

Father and Son:

Yeeses..., oh yes!

Museum:

Thus the Pendulum has proved that the stars system of reference is — as is said — an *inertial* or *galilean* system: Son, relatively to this system, without any driving force, you will go on straight ahead, keeping constant your speed, but not relatively to the Earth, *not* relatively to the Earth! And, relatively to this *very peculiar* system, in which things become *simple*, our Earth is rotating. This gives right definitively to Galileo, and Copernicus, and Aristarchus of Samos — this last one already more than two centuries before Christ. But could Galileo reach such an ultimate conclusion? Too early. In 1633, the concepts are not ready, they will require yet time before becoming

obvious. But the copernicans had the right intuition and point of view, thus giving way to the discovery of the law of Gravitation and to a full understanding of the solar system.

Father and Son:

Ah, thank you very much!

Museum:

Now, Father and Son, I will lead you to the Equator and show how the Pendulum no longer rotates there — and why — and what happens in the southern hemisphere.

But, anyway, let us have a stop in Pognana, a wonderful place in Italy!

Now, Aristarchus, Copernicus, Bellarmine — oh, Bellarmine? Hum, not you Saint-Robert, remain where you are, *nel Paradisio o nel Inferno* — now, Aristarchus, Plutarch, Copernicus, Galileo, Newton, Poincaré, Einstein,

altogether

alle zusammen

tous en coeur,

andiamo a Pognana per una giornata al sole!

Father and Son:

(throwing their arms up in the air)

Whow!

THE END

The actors bow to the audience.

Acknowledgements

Dr. Jürgen Teichmann, from Deutsches Museum, is gratefully acknowledged for having suggested the starting idea of Father and Son before the Pendulum: “But this, I know definitely, I don't need the demonstration!”. Dr. Don Metz from the University of Winnipeg (Canada) and Dr. Roland Wittje, from the University of Trondheim (Norway) are warmly thanked for having so brilliantly acted in the roles of Father and Son respectively.

References

Baudelaire, C.: 1862, *The Poems and Prose Poems of Charles Baudelaire*, Ed. James Huneker, Brentano's, New York (1919); 1862-1959, *Les Fleurs du Mal*, Paris.

De Santillana, G.: 1955, *The crime of Galileo*, New-York; 1955, *Le Procès de Galilée*, Paris; 1960, *Processo a Galileo*, Mondadori.