measurable effects of the ether was based upon two "principles". According to him,

(1) The angles of incidence and reflection of light could be different, relative to the proper reference system of the mirror, if it moved through the ether.

(2) The Lorentz contraction of the Earth due to its motion through the ether produced observable effects relative to the Earth's reference system.

Both "principles", of course, violate the principle of relativity, but Courvoisier presented theoretical arguments attempting to show that there should exist second order measurable effects. He searched for those effects using both astronomical observations and laboratory experiments and claimed that he had measured a velocity of the solar system of about 600 km/s in a direction close to 75 degrees right ascension and +40 degrees declination.

This paper will present a description and analysis of the astronomical part of Courvoisier's work.

INTRODUCTION

Leopold Courvoisier was born on the 24th January 1873 in Rihen near Basel (Switzerland)[1]. His father Ludwig Georg Courvoisier was a physician and was in charge of the surgery chair of the University of Basel. Leopold passed away in the same city where he was born, on the 31st December 1955. However, most of his professional life was spent in Germany.

Courvoisier exhibited an interest for astronomy since he was 15 years old. In 1891 he began his university studies, first in Basel and later in Straßburg. In 1897 he completed his dissertation on the absolute height of the pole as observed from Straßburg (“Die absolute Polhöhe von Straßburg”). In 1898 he became an assistant observer at the Königstuhl Astronomical Observatory near Heidelberg, under W. Valentiner. In 1900 he obtained his Doctor degree in Straßburg. From 1905 onward he worked at the Berlin-Babelsberg Observatory as an astronomical observer, under the direction of Karl Hermann Struve[2]. In 1913 the new Babelsberg Observatory was founded, and in 1914 Courvoiser became its chief observer and professor. He worked at Babelsberg up to his retirement in 1938, when he was 65 years old. In 1943 he moved to his birthplace, where he kept making observations and publishing papers up to his death. He was also the editor of several of Leonhard Euler's astronomical works.

Courvoisier’s main astronomical contribution was a large series of routine astrometrical observations that helped to establish star catalogues. Volumes 5, 6 and 7

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[1] For biographical information, see Courvoisier's necrology: RICHTER, 1957.

[2] Courvoisier wrote Struve’s obituary: COURVOISIER, 1921c.

had measured a velocity of the solar system of about 600 km/s in a direction close to 75 degrees right ascension and +40 degrees declination.

The papers describing those researches were published in several scientific journals – especially *Astronomische Nachrichten*, *Physikalische Zeitschrift* and *Zeitschrift für Physik*. His work was largely ignored and had a negligible repercussion. Only a few authors (e.g. Ernest Esclangon, Dayton Miller) who also claimed they had observed effects due to the ether have cited his works. Historians of science have also neglected those researches[3]. However, it is relevant to study Courvoisier's works, because they present the largest set of empirical results that was ever published against the theory of relativity by a professional scientist. Courvoisier's researches exhibited an outstanding theoretical and experimental skill. His results can be regarded as the strangest puzzle of the history of relativity.

COURVOISIER AND RELATIVITY

The first direct relation between Courvoisier's work and relativity was an outcome of his routine measurements of star positions. Since 1905 Courvoisier had noticed that the right ascension and declination of fixed stars suffered a small influence when they are observed close to the Sun. As this influence had a period of one year, he called it "annual refraction". His first work on the subject was published in 1905, that is, much earlier than the development of the general theory of relativity (COURVOISIER, 1905). In 1911, after the publication of Einstein's early thoughts on the gravitational deflection of light rays close to the Sun, Erwin Freundlich recalled that Courvoisier's work had exhibited an effect that was qualitatively similar to the one predicted by Einstein (HENTSCHEL, *The Einstein tower*, pp. 10-11). However, Courvoisier interpreted the effect he had measured as due to refraction of light by a denser medium around the Sun. It seems that Courvoisier's opposition to Einstein's work grew steadily from this time onward and he became one of the most intransigent supporters of ether theory after the theory of general relativity received strong confirmation (the eclipse measurements), in 1919.

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[3] Klaus Hentschel studied some of Courvoisier's works (HENTSCHEL, *The Einstein tower*; HENTSCHEL, 1994) but he did not refer to the researches described in this paper.

Courvoisier that those measurements could be used to measure the speed of the Earth through the ether.

Courvoisier accepted that there was a static ether, similar to the medium proposed in the early 18th century by Augustin Fresnel. This theory led to the conclusion that there could be no first-order influence of the motion through the ether upon optical experiments performed in the Earth. Besides that, the negative outcome of the Michelson-Morley experiment required an additional hypothesis, and Courvoisier accepted that motion through the ether produced a real contraction of all moving bodies, according to the explanation proposed by Fitzgerald and Lorentz.

According to Lorentz's theory, the principle of relativity would hold exactly for any optical or electromagnetic phenomenon, but Courvoisier did not follow Lorentz's theory. He directly denied the principle of relativity and attempted to measure the motion of the solar system through the ether using several different techniques.

Courvoisier assumed that the reflection of light in a mirror could undergo some influence of the motion of the mirror through the ether, *even when the effect was observed relative to the proper reference system of the mirror*. Any observable effect should be of the second order in v/c. It would be impossible to detect such a small effect if the speed of the Earth relative to the ether was about 10^{-4} c (that is, its orbital velocity), because for usual angle measurements (let us say, 60°) a difference of 10^{-8} would amount to only 0.002" – an effect that could not be observed. However, Courvoisier assumed that there could exist a much larger speed of the whole solar system relative to the ether, and analyzed the data published by the Leyden Observatory.

He computed the difference z'–z between the direct zenith distance and reflected zenith distance of the stars listed in the catalogue, attempting to find a systematic effect that varied in a periodic way with the sidereal time of observations. Using a graphical method he did find such an effect, and he soon submitted the data to quantitative analysis. He derived an equation to describe the reflection of light in a moving mirror and determined its parameter from an analysis of the Leyden data, using the method of minimum squares. He obtained an effect corresponding to a speed of about 800 km/s in the direction of the Auriga constellation. This speed is, of course, much larger than the

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[4] Klaus Hentschel claimed that Courvoisier derived the speed of the Earth's motion through the ether from his data on annual refraction (HENTSCHEL, *The Einstein tower*, p. 11), but his data for the computation of the speed of the Earth was taken from completely independent sources, as will be shown in this paper.

Of course, it is impossible to measure the angle between the local vertical and the axis of rotation of the Earth. However, as this axis has a fairly constant direction relative to the fixed stars, it is possible to choose a star very close to the North celestial pole and to measure its distance to the zenith (that corresponds to the local vertical direction). This angle, according to Courvoisier's theory, should undergo a periodical change, as a function of the sidereal time.

Courvoisier realized that, by a lucky chance, he had already measured the position of a star very close to the North pole, in a long series of observations from 1914 to 1917 (COURVOISIER, 1919), using the Babelsberg Observatory vertical circle[6]. Those measurements were very precise and were evenly distributed as regards the sidereal time of the observations. They were therefore suitable for looking for the influence of the Lorentz contraction on astronomical measurements.

As in the former case, Courvoisier plotted the zenithal distances of the star against sidereal time, and found a regular fluctuation of the angle. He then developed an equation to account for the effect, analyzed the data using the minimum square method, and obtained his second measurement of the velocity of the Earth relative to the ether. The speed obtained in this case was about 700 km/s, in the direction of the constellation of Perseus (not very far from Auriga). Courvoisier regarded the agreement of those two earlier results as satisfactory, and this led him to further researches.

There was a delay of 5 years between Courvoisier's first positive results and his next publication on the subject (COURVOISIER, 1926). In this period he accumulated a series of positive results by different methods, developed the equations required for the analysis of his data, and devised new methods for measuring the absolute speed of the Earth. This delay shows that Courvoisier was careful enough to resist publishing preliminary results before he was able to amass a large amount of evidence for his claim.

THE METHOD OF THE MOVING MIRROR

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[5] A few years later, Courvoisier obtained new data, using the same method (direct versus reflected direction). Using the vertical circle of the Babelsberg Observatory, he made a long series of observations (1921-1922) that led to results similar to those that had been obtained from the Leyden observations.

[6] Courvoisier had made this series of measurements as routine observations to find out the latitude of the Babelsberg Observatory. The method used by Courvoisier is very precise, and was recently used for the determination of the azimuth of a transit instrument in Brazil (TEIXEIRA & BENEVIDES-SOARES, 1986).

θ = sidereal time of measurement

A straightforward geometrical analysis shows that the components of v/c are:

$$\alpha = (v/c)\,[\cos\phi \sin D - \sin\phi \cos D \cos(\theta - A)]$$
$$\beta = (v/c)\,[\sin\phi \sin D + \cos\phi \cos D \cos(\theta - A)]$$
$$\gamma = -(v/c) \cos D \sin(\theta - A)$$

In Courvoisier's first method, as described above, light was reflected by a mirror, and it was also necessary to study the effect of the motion of the mirror through the ether upon the direction of the reflected ray. Courvoisier made use of the non-relativistic analysis developed by Harnack (1912), that predicted that the angle of reflection should be different from the angle of incidence, relative to the proper reference system of the mirror.

Taking into account this "principle of the moving mirror", Courvoisier predicted that the angle between the local vertical (zenith) and the direction of observation of a given star would be slightly different from the angle between the zenith and the direction of the star observed through a mercury mirror. In this specific case, the contraction of the Earth could produce no effect, because both measurements were made relative to the same reference (the local vertical) and the mercury horizontal mirror is, of course, perpendicular to the local vertical, whatever the changes that the gravitational field could undergo because of the Lorentz contraction.

The predicted effect was a small systematical difference between the direct and the reflected angles, which should depend on the direction of the observatory relative to the motion of the Earth through the ether.

Let θ be the angle of incidence and θ' the angle of reflection of a light ray in a moving mirror, measured relative to the ether[8]. According to Harnack's analysis, instead of $\theta = \theta'$ the following equations would hold (HARNACK, 1912):

$$\sin\theta' = (1 - \beta^2) \sin\theta \,/\, (1 + 2\beta \cos\theta + \beta^2)$$

[7] Courvoisier never published the details of his derivations – he only presented his main assumptions, a few steps and the final results. In all relevant cases, however, I have been able to confirm the Courvoisier's equations do follow from his assumptions.

[8] In his equations Courvoisier used θ as a symbol of sidereal time, but in this particular derivation we are following Harnack's notation.

$$z' = \theta' + \alpha \cos \theta' + \beta \sin \theta'$$

where α is component of the velocity v/c of the mirror parallel to its surface. Notice that this is the classical aberration effect. A relativistic analysis would lead to a different result.

The measured effect is the difference between z' and z:

$$z' - z = (\theta' - \theta) + \alpha (\cos \theta' - \cos \theta) + \beta (\sin \theta' - \sin \theta)$$

Taking into account the above equations and making suitable substitutions, one obtains the approximate result:

$$z' - z = 2\alpha\beta \sin^2 z$$

Replacing α and β by their equations[9]

$$\alpha = (v/c) [\cos \phi \sin D - \sin \phi \cos D \cos (\theta - A)]$$
$$\beta = (v/c) [\sin \phi \sin D + \cos \phi \cos D \cos (\theta - A)]$$

one obtains:

$$z'-z = [(v/c)^2 \sin^2 z].[\sin 2\phi.\sin^2 D + \cos 2\phi.\sin 2D.\cos (\theta-A) - \sin 2\phi.\cos^2 D.\cos^2(\theta-A)]$$

Notice that in this equation there is a constant term and two periodical components with different periods – one sidereal day [cos (θ–A)] and half a sidereal day [$\cos^2$ (θ–A)]. Therefore, from a suitable analysis of the data it should be possible to obtain the speed (v/c), the declination (D) and the right ascension (A) of the motion of the Earth relative to the ether.

REPETITIONS OF THE LEYDEN MEASUREMENTS

The Leyden measurements had used four stars close to the North Pole. The difference z–z' was measured in a series of different days, at the times of the upper and lower

[9] From this point onward, θ is used again to represent sidereal time.

Therefore his measurements were not limited to two sidereal times for each star.

From 4 June to 14 December 1921 he made a series of 142 measurements, and from 18 March to 23 May 1922 he made other 64 measurements of z–z'. He observed the polar star BD +89.3°. From those measurements Courvoisier obtained:

A = 93° ± 7°

D = +27° ± 12°

v = 652 ± 71 km/s

The error of the speed was reduced to about 10% and the errors of the right ascension and declination amounted to less than 1/30 of the full circle.

Other series of measurements were later obtained in München (1930-1931) and Breslau (1933-1935), with the following results:

München	Breslau (1)	Breslau (2)
A = 73° ± 6° D = +40° (estimated)[10] v = 889 ± 93 km/s	A = 92° ± 12° D = +44° ± 25° v = 927 ± 200 km/s	A = 80° ± 4° D = +30° ± 10° v = 700 ± 60 km/s

The results obtained in the second Breslau series presented the smallest errors.

In 1945, after his retirement, Courvoisier made a final series of observations from Basel. He obtained the following results:

A = 60° ± 14°

D = +40° (estimated)

v = 656 ± 157 km/s

If we compare all the series of measurements, we notice that the right ascension varied between 60° and 104° (more than the estimated errors); the declination varied between 39° and 44° (within the estimated errors)[11]; and the speed varied between 652 and 927 km/s (within estimated errors).

Notice that it is very hard to explain away Courvoisier's results as due to instrument errors, because the observed effect varied with periods of one sidereal day and half sidereal day. All common causes of error (gravity changes, temperature changes, etc.)

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[10] In some of his analysis, Courvoisier found that the effect with one sidereal day period was not clearly noticeable. In those cases, he assumed the value of 40° for the declination, and computed the right ascension and speed of the Earth.

[11] The slight variations of the values found for the declination led Courvoisier to assume this value as known, as remarked above, in all cases when it was impossible to compute A, D and v/c.

Accordingly, Courvoisier was led to build a new instrument: an optical device for measuring absolute motion (COURVOISIER, 1927a, 1927b). He used two small telescopes that were placed in a cave where the temperature was fairly constant. Both telescopes pointed obliquely (zenithal distance = 60°) to a mercury mirror that was placed between them. They were mounted in a vertical plane in the East-West direction. One of the telescopes had a small electric light close to its reticule, and this was the light source that was observed from the second telescope. Both telescopes were first adjusted so that it was possible to see the reflection of the illuminated reticule of the first telescope from the second telescope. They were then fastened in those directions. Of course, the angles of the telescopes with the local vertical were sensibly equal. The experiment did not try to measure any difference between those angles. It attempted to detect small periodical changes of the position of the reticule of the first telescope as observed from the second one. The apparent motion of the reticule was measured with the aid of the ocular micrometer of the second telescope.

With this device, Courvoisier made two series of observations in 1926 and 1927. Afterwards, he had a special instrument built for this purpose, and made a third series of observations in 1932.

As described above, the telescopes were placed in a vertical plane in the East-West direction. In 1926 and 1928 Courvoisier built two new instruments that could be rotated and that he expected that the new kind of instrument would improve his measurements. However, he found out that it was impossible to compare measurements when the instrument was rotated, and the instrument could only be used in a fixed position.

The equation used to compute the effect was similar to the equation used in the case of the observation of stars, but instead of the North component of the speed, it was necessary to take into account the West component. As in the former case, the resulting equation has a constant term plus variable components with periods of one sidereal day and half sidereal day.

The first series of measurements was made from 31 July and 6 August 1926, with observations spanning between 3 and 20 o'clock sidereal time; and the second one from 28 February to 29 May 1927, with observations covering the period from 21 and 13 o'clock sidereal time. Both series comprised more than 500 measurements. This table shows the mean results obtained by Courvoisier for each sidereal time:

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[12] Tidal influences due to the Moon would have periods that could be easily distinguished from the effects predicted by Courvoisier.

21.91 h	+ 0.21"	38
23.32 h	+ 0.08"	45

Second series:		
Sidereal time θ	**(z – z') + constant**	**number of measurements**
2.9 h	+ 1.54"	4
7.3 h	+ 0.28"	6
8.2 h	+ 0.28"	7
9.1 h	– 0.01"	7
10.1 h	+ 0.23"	6
11.4 h	+ 0.56"	5
12.3 h	+ 0.60"	5
13.7 h	+ 0.52"	7
15.5 h	+ 0.84"	6
17.9 h	+ 0.88"	7
19.9 h	+ 0.80"	7

The first series comprised 489 observations, and the second series only 67 observations. From the first series, Courvoisier computed the following values:

A = 70° ± 6°

D = +33° ± 11°

v = 493 ± 54 km/s

From the second series, he obtained the results:

A = 22° ± 6°

D = +72° ± 11°

v = 606 ± 45 km/s

Of course, the results obtained from the first series of measurements were more reliable than those from the second series were, and they exhibited a closer agreement with former measurements.

Notice that, although those measurements attempted to detect the same kind of effects as the astronomical observations – that is, a difference between angle of incidence and angle of reflection in a moving mirror – the astronomical observations used the North-South direction, and the cave experiments employed the East-West

Courvoisier computed the following values:

$A = 74° \pm 1°$

$D = +36° \pm 1°$

$v = 496 \pm 10$ km/s

THE SECOND METHOD: LORENTZ CONTRACTION

As described above, Courvoisier's second attempt to measure the absolute velocity of the Earth was grounded upon his analysis of the Lorentz contraction of the Earth. In this case, Courvoisier supposed that the local vertical would undergo a change, due to the Lorentz contraction of the Earth, and this change would be observable as a periodical fluctuation in the angle between the North Pole and the zenith, as a function of the sidereal time.

Courvoisier's theoretical analysis led him to predict that the variation of the zenithal distance Δz of a star close to the North Pole would obey the approximate relation:

$$\Delta z = \tfrac{1}{2}\, \alpha\beta$$

There are some special observational difficulties in this second method. If it were possible to observe a star laying *exactly* in the direction of the celestial North Pole, the theory would be simple. However, if the star is not exactly in the direction of the pole, its zenithal distance will depend on the sidereal time of the observation. This completely classical large effect would have, therefore, a period of one sidereal day and would interfere with any attempt to measure an effect due to the motion through the ether with a period of one sidereal day. Other interfering effects, such as temperature changes, vary with a period of about one solar day, and they are very large and irregular. For those reasons, Courvoisier gave up the attempt of finding the amplitude of the sidereal day effect, and only computed the half sidereal day effect. It was impossible, therefore, to find all parameters, and he assumed a value of 40° for the declination, and computed the speed and right ascension of the motion of the Earth relative to the ether. Dropping out the component corresponding to the period of one sidereal day, he obtained:

$$\Delta z = -(1/4)(v/c)^2 . \sin 2\phi \,(\text{const.} - \cos^2 D . \cos^2(\theta - A))$$

$v = 810 \pm 166$ km/s

Afterwards Courvoisier also computed the motion of the Earth using measurements from Breslau (1923-1925 and 1933-1935) and from München (1927-1931). Taking into account all the observations, he obtained the following final result:

$A = 65° \pm 10°$

$[D = +40°]$

$v = 574 \pm 97$ km/s

COMPARISON BETWEEN MEASUREMENTS FROM DIFFERENT PLACES

The effects predicted by Courvoisier as a consequence of the Lorentz contraction of the Earth should depend on the latitude of the observatory. For that reason, if the same set of stars was observed from two observatories at very different latitudes, there should exist a systematic difference between the measured declinations of the stars, as a function of sidereal time.

To test the existence of this effect, Courvoisier analyzed the catalogues containing measurements made at Heidelberg ($\phi_1 = +49.24°$) and at Cape Town, South Africa ($\phi_2 = -33.48°$). Let D_1 be the declination of some star measured from Heidelberg, and D_2 the declination of the same star measured from Cape of Good Hope. Each declination, according to Courvoisier's analysis, undergoes a periodical change:

$$\Delta z_1 = \tfrac{1}{2}\, \alpha_1\beta_1 \qquad\qquad \Delta z_2 = \tfrac{1}{2}\, \alpha_2\beta_2$$

Those effects are not equal, therefore, the difference between the declinations measured at the two observatories should undergo a periodical change:

$$D_1 - D_2 = \tfrac{1}{2}\,(\alpha_1\beta_1 - \alpha_2\beta_2)$$

Using the values of A=75° and D=40° obtained in former measurements, and taking into account the latitudes of Heidelberg and Cape Town, Courvoisier predicted that there should exist a difference between the measured declinations of the stars that should depend on their right ascension α:

$$D_1 - D_2 = +0.16'' - 0.18''.\cos(\alpha - 5\text{ h}) - 0.16''.\cos 2(\alpha - 5\text{ h})$$

5 h	+ 0.03"	+ 0.03	– 0.17"
6 h	+ 0.17"	+ 0.17	– 0.14"
7 h	– 0.03"	– 0.03"	– 0.06"
8 h	+ 0.07"	+ 0.07"	+ 0.04"
9 h	+ 0.10"	+ 0.10"	+ 0.14"
10 h	+ 0.08"	+ 0.08"	+ 0.25"
11 h	+ 0.09"	+ 0.09"	+ 0.32"
12 h	+ 0.29"	+ 0.29"	+ 0.34"
13 h	+ 0.32"	+ 0.35"	+ 0.32"
14 h	+ 0.29"	+ 0.39"	+ 0.29"
15 h	– 0.04"	+ 0.22"	+ 0.25"
16 h	– 0.21"	+ 0.13"	+ 0.20"
17 h	– 0.23"	+ 0.18"	+ 0.19"
18 h	– 0.29"	+ 0.12"	+ 0.20"
19 h	– 0.31"	+ 0.10"	+ 0.23"
20 h	– 0.17"	+ 0.17"	+ 0.29"
21 h	+ 0.04"	+ 0.30"	+ 0.33"
22 h	+ 0.26"	+ 0.36"	+ 0.34"
23 h	+ 0.38"	+ 0.41"	+ 0.32"

The third column of the table presented the observed values corrected for null declination, in order to avoid classical errors due to atmospheric refraction, etc. There is a better agreement between the theoretical prediction and the corrected values than with the raw data.

NADIR OBSERVATIONS

In his analysis of the second method Courvoisier assumed that the Lorentz contraction of the Earth produces a local periodical change of the direction of the gravitational field. This effect was not compensated by changes in the direction of the astronomical instruments. Therefore, he was led to think that the effect also could be measured in an experiment using a terrestrial light source.

He placed a mercury mirror directly below a meridian circle and pointed the telescope downward. It was then delicately adjusted in such a way that it was possible to observe the reflected image of the micrometer threads superimposed to the real threads.

v = 920 ± 73 km/s

Applying a temperature correction, he obtained the following results:

A = 98° ± 7°
D = +25° ± 11°
v = 500 ± 47 km/s

This experiment was repeated by A. Kopff, of the Heidelberg Observatory, from 10 to 29 June 1923. As in the case of Courvoisier's experiment, there was a strong effect due to temperature changes (temperature varied between +6°C and +17°C). Courvoisier analyzed Kopff's data assuming the values A = 75° and D = +40°. After applying temperature corrections, he obtained a speed of 753 ± 57 km/s.

OTHER METHODS

Courvoisier also attempted to detect the motion of the Earth relative to the ether by other methods. The positive result of the nadir observation method confirmed his hypothesis that the Lorentz's contraction produced an observable periodical change of the local vertical. He soon devised other ways of observing such an effect.

Plumb line motion

One of the instruments he used was a plumb line attached to one of the columns of the Babelsberg observatory. The main body of the plumb line was a 95-cm metallic rod. At its lower end there was a mark that was illuminated and projected upon a wall. It was possible to observe deflections of about 0.05" of the direction of the plumb line, in the East-West direction. The measurements made in 1925 with this instrument led to a speed of the Earth of about 400 km/s, assuming A = 75° and D = +40° . In 1931 Courvoisier improved this instrument observing the motion of its tip with the aid of a microscope (COURVOISIER, 1932c). Now he was able to compute the three parameters of the Earth's motion:

A = 64° ± 6°
D = +50° ± 9°
v = 367 ± 29 km/s

Bubble levels

Another way of observing the variation of the local vertical direction, according to Courvoisier, was with the aid of bubble levels (COURVOISIER, 1930a; 1934). He used two very sensitive level meters. One of them was attached to the floor of the Babelsberg direction of its motion through the ether, and this contraction would produce observable periodical changes of the local value of gravity as a function of sidereal time. Pendulum clocks at different places of the Earth should show slightly different readings, and their phases should exhibit a periodical relative fluctuation. Courvoisier analyzed data on pendulum clocks of different astronomical observatories, in an attempt to detect this effect.

Using radio signals it was possible to compare the rates of clocks at very distant observatories. The Annapolis Observatory emitted regular time signals from its pendulum clocks. It was possible to compare the rate of those pendulums to those at another place. Courvoisier asked the help of O. Wanach, from Potsdam, who compared the rate of the pendulum clocks of that observatory to the signals received from Annapolis, from September 1921 to November 1922 (COURVOISIER, 1927a). Courvoisier's analysis of Wanach's data led to the following results:

$A = 56° \pm 12°$

$D = +40°$ (estimated)

$v = 873 \pm 228$ km/s

Afterwards, a comparison was made using a comparison between the clocks of Annapolis, Potsdam, Ottawa, and Bordeaux. The mean result obtained by Courvoisier was:

$A = 81° \pm 5°$

$D = +34° \pm 5°$

$v = 650 \pm 50$ km/s

Much later, Courvoisier presented another confirmation of this effect. He compared the catalogues of time correction of the observatories of Greenwich, Potsdam, Buenos Aires and Mount Stromslo for the period from 1948 to 1954 (COURVOISIER, 1954, 1957). There was a nice agreement between the theoretical predictions and the observed time differences, especially in the case of the years 1951-1954.

Local comparison between pendulum clock and chronometer

Courvoisier supposed that the rate of pendulum clocks would vary because of the periodical gravity changes, but mechanical chronometers should not suffer similar changes. Therefore it should be possible to observe effects due to the absolute motion of the Earth comparing pendulum clocks to mechanical chronometers at a single place. Comparisons were made both at Babelsberg and at Potsdam (with the help of Wanach). In his analysis, Courvoisier assumed the value $D = +40°$ and obtained $A = 104° \pm 9°$ and $v = 750$ km/s.

In 1932 Courvoisier obtained new results, taking into account in this new paper some effects due to temperature and humidity. The new results obtained by him were

A = 50° ± 7°

D = +45° ± 18°

v = 498 ± 78 km/s

For the first time, Courvoisier's results were criticized and checked. In 1932, R. Tomaschek and W. S. Schaffernicht reported gravity measurements made with a new kind of gravimeter that was able to detect changes $\Delta g/g$ of 10^{-8}. The instrument was placed inside a cave in a mountain, where the temperature was constant to 0.001°. No effect of the order of magnitude predicted by Courvoisier was observed (TOMASCHEK & SCHAFFERNICHT, 1932).

Eclipses of Jupiter's satellites

It is well known that in 1879 James Clerk Maxwell wrote to David Peck Todd asking him about the possibility of computing the velocity of the solar system through the ether using available data on occultation of Jupiter's satellites. Maxwell supposed that the motion of the solar system would produce an anisotropy of the speed of light that could be detected as a fluctuation of the times of occultation of Jupiter's satellites, observed from the Earth, with a period of about 12 years. Todd answered, however, that the measurements available at that time were not precise enough for such computations.

In 1930 Courvoisier published a paper where he presented an analysis of available observations of Jupiter's satellites and claimed that they led to a new determination of the velocity of the solar system relative to the ether (COURVOISIER, 1930b). He used data relative to the three inner Galilean satellites published by the Johannesbourg Observatory (1908-1926), comparing those measurements to those of the observatories of Cape Town, Greenwich and Leyden (1913-1924). He confirmed Maxwell's anticipation of a fluctuation with a period of about 12 years and obtained the following results:

A = 126° ± 10°

D = +20°

v = 885 ± 100 km/s

Secular aberration of light

According to the theory of ether accepted by Courvoisier, the speed of light is constant relative to the ether, but could not be constant relative to the Earth: there should be an observable anisotropy of the speed of light due to the absolute motion of contemporaries.

Courvoisier measured the velocity of the Earth relative to the ether using several different methods. The effects he was searching for were very small (second order in v/c) but the results presented were significantly larger than the estimated experimental error. The measured values of the right ascension of the Earth's motion apex varied from 52° to 126°, with a strong concentration of values between 60° and 90°. The measured declination varied between +27° and +55°, most values falling between +34° and +46°. The values obtained for the speed of the Earth varied between 300 km/s and 927 km/s, most results falling between 500 km/s and 810 km/s.

Notice also that Courvoisier was a professional astronomer, and his routine measurements were always accepted and used without further questioning. Why did the scientific community ignore Courvoisier's anti-relativistic results? Several factors may have contributed to that attitude:

1. In the 1920's Einstein's theory had been successfully confirmed and most physicists and astronomers were convinced that it was the correct theory. Attempts to bring the ether again to life seemed too old-fashioned and most scientists would not be willing to hear or to read about such attempts[13].
2. Many of Courvoisier's papers were published in the *Astronomische Nachrichten*, a journal that was clearly opposed to Einstein's theory. Most scientists supporting the theory of relativity would dismiss any anti-relativist account published in that journal[14].
3. Courvoisier's did not build a comprehensive theory that could be regarded as an alternative to the theory of relativity. He used a strange combination of classical physics together with the hypothesis of Lorentz's contraction, and never published a detailed derivation of his equations.
4. The observed effects were very small (usually a few tenths of arc-second) and there were always large relative fluctuations of the measurements. Any single measurement published by Courvoisier could be regarded as the result of random or unknown systematic errors. The agreement between different measurements could be regarded as due to chance, or to a process of "cooking" the results.

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[13] This was also the main reason why Quirino Majorana's measurements of the absorption of gravitation and Kurt Bottlinger's explanation of the anomalies of the motion of the moon using the same assumption were dismissed by the scientific community (MARTINS, 1999).

[14] Information concerning Courvoisier's scientific supporting circle is not yet available. The editor of *Astronomische Nachrichten* was Hermann Kobold (1858-1942), who rejected the relativity theory and supported the publication of anything that went against it, regardless of its scientific merit.

data, described experiments he never made, "cooked" his results, and so on. In that case, it would be especially relevant to find out evidence that he really did so, and information on his motivation. In that case, the attitude of the scientific community is to be regarded as a "normal" reaction, but nevertheless it would be desirable to find out whether there was clear public evidence that Courvoisier was not an honest scientist.

- Alternatively, one could assume that Courvoisier was an honest scientist and that he did observe what he described, and correctly computed his results. It that case, it would be specially relevant find evidence that his accounts were faithful and results he presented do really follow from the raw data available; it would be highly relevant, too, to understand the lack of acceptance of his results by the scientific community.

In both cases, it would be desirable to locate unpublished correspondence and other documents of the time that could elucidate both Courvoisier's campaign against relativity and the silence of the scientific community concerning his work.

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