

Adjusting Astronomical Practices: The “Carte du Ciel”, the democratic rules and the circulation of opinions at the end 19th century

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Abstract. Launched in 1887, the “Carte du Ciel” was an international project aiming at photographing the entirety of the celestial vault. Tasks required for this huge undertaking were divided among 18 observatories around the globe. Instruments were standardized and a series of international conferences established operating modes and prescribed norms to be followed everywhere. In each observatory, however, the drive toward uniformity ran into a variety of minor technical and practical problems. In this paper, we examine the strategies mobilized by observers to tinker with stated rules and adapt them to their own experience as astronomers. To underscore the tension between normative prescriptions and individual practices, we consider the *Bulletin of the Permanent International Committee for the execution of the Carte du Ciel* as an informal forum where various queries raised and arrangements adopted were shared among the scientific community.

Keywords. astronomy, Carte du Ciel, scientific practices

1. Introduction

The Carte du Ciel, initiated by Ernest Mouchez of the Paris Observatory and David Gill, director of the Observatory of the Cape of Good Hope, mobilized eighteen observatories throughout the world. The goal of this international scientific program was to map the sky thanks to photography (Lankford 1984; Jones 2000). In fact, the Carte du Ciel employing the recent developments in photography combined, at the end of the 19th Century, a traditional astronomical theme (inventory of the sky) and a recent technology technology, at the end of the 19th century (photography). The Carte du Ciel required a large co-operation on a world scale. It was founded on the definition of common rules for all the astronomers. In this paper I will examine the way in which is organized the scientific co-operation between the observatories participating in the Carte du Ciel. I will detail the role of the international conferences which met in Paris in 1887, 1889 and 1891. Then I will study the *Bulletin of the Permanent International Committee for the execution of the Carte du Ciel*, in order to understand how practices coordinated with one another.

2. The project of the Carte du Ciel

In 1880 Ernest Mouchez, director of the Paris Observatory was particularly interested in development of photography for astronomical applications. In the United States, William C. Bond undertook work on astronomical photography (Mouchez 1887) and in

England, Warren De La Rue also made experiments on the subject (Chinnici 1999). In France Léon Foucault and Hippolyte Fizeau obtained photographs of the Sun of very good quality in 1842 and 1843 (Tobin 2002). In 1879, Ernest Mouchez created a photographic laboratory within the Paris Observatory (Baillaud 1935). Then, he encouraged the brothers Paul and Prosper Henry, opticians and astronomers at Paris Observatory, to build photographic equatorials. They started by developing a camera with an objective of 16 cm. Then, in 1885, the two brothers delivered a camera of 33 cm (Mouchez 1887). Ernest Mouchez was filled with enthusiasm by the quality of the instrument. He considered that the photographic objective of the Henry brothers “goes far beyond all that was made up to now in France or abroad for the photography of stars” (Mouchez 1887). In the Cape of Good Hope, David Gill also wondered about the possible applications of photography to an astronomical program. The southern sky was rarely observed before the end of the 19th century. The catalogs of southern stars were few. Ernest Mouchez and David Gill came in contact and conceived a celestial project of cartography. Their objective was to use photography, not to reproduce the aspect of the stars, but to determine their position. Ernest Mouchez spoke about a “geography of the sky” (Mouchez 1887). He wanted the Carte du Ciel to enable the study of “the distribution of stars in space”. Thus the gauges of Herschel “will be exceeded and made useless” (Mouchez 1887). The director of Paris Observatory insisted on the transformation of the astronomical practice which photography allows. He noticed that the photographic plate has a greater sensitivity than the human eye : it can distinguish several hundreds of stars where the eye sees only one compact mass of stars. The observer is no longer at the focus of the instrument ; he examines the photographic plates with a microscope. The astronomer does not observe directly any more in the dome. It is thus possible to transport the image of the sky “into the study” (Mouchez 1887). Lastly, the plates can be reproduced at will and thus circulate easily among astronomers. The project of the Carte du Ciel thus rested on the search for a higher degree of accuracy and as well as on the mechanization of the operations. One can notice that the Carte du Ciel is a scientific program of traditional astronomy (the celestial inventory), associated with an innovating technique, the photographic one. The project was very ambitious. It made it possible to obtain the positions of more than two million stars in ten or twenty years. Ernest Mouchez wanted to gather the astronomers interested by his project. He contacted the Royal Astronomical Society of London in 1885 (Baillaud 1935). He wrote to the directors of the observatories of Harvard, London, Rio and Poulkovo (Chinnici 1999). The reception was very favorable. David Gill was enthusiastic. He even proposed to add to the photography of the sky the construction of a catalog of positions of the stars. Gill urged Mouchez to organize an international conference (Gill 1888).

This great meeting was held in Paris in April 1887. It gathered 56 members of 38 nationalities. After one week of discussions, the objective was laid down : “*to note the general state of the sky at the current time [and] to obtain data which will make it possible to determine the positions and the sizes of all stars until an order of magnitude (...)*” (Congrès 1887). Paris Observatory was at the center of a world-wide network of 18 observatories. The first question to be settled concerned the distribution of the zones of the sky to be photographed by each observatory. William H. Christie, director of the Greenwich Observatory noticed that the observatories of the southern hemisphere (fewer than in the northern hemisphere) would have to make more photography (*Bulletin* 1890). In 1891, the observatories received the co-ordinates of their zones of observation. Almost all the observatories received identical photographic equatorials, each with an objective of 33 centimeters. The Carte du Ciel required three distinct operations. The first consisted in measuring the positions of stars with a meridian instrument. The second step was to

take the photographs and develop them. Third was the determination of the positions of the stars on the plates. The very large quantity of stars to be measured prevented the astronomers from carrying out all calculations. They created services of calculations in their observatories. Some observatories (as that of Paris) entrusted these calculation offices to female employees.

3. The parliament of the Carte du Ciel

The international Conferences, of 1887, 1889 and 1891 defined a whole of rules to be followed for the practice. Ernest Mouchez asked that “*the final and uniform bases survey of the Carte du Ciel (...)*” be fixed (Mouchez 1888). The execution, the development and the measurement of the photography were thus framed. Each operation was detailed. For example, in 1889, a resolution indicated the manner of ordering and of filing the photographic plates (Trépiéd 1892). The organizers of the Carte du Ciel required a standardization and uniformity of the practices. In particular, that applied to the calibration of the observers. The personal equation of each of them was measured for the evaluation of the sizes of the stars on the plates (Baillaud & Baillaud 1906). The first recommendations of the Carte du Ciel were very prescriptive. This organization of the scientific activity falls under a broader movement of transformation of the observatories into scientific factories. The industrial model became dominant at the end of the 19th century, with division of labor, the definition of the tasks and the standardization of the instruments. However, this regulation of the practices within the framework of the Carte du Ciel quickly caused resistance. For example, the exposure time was fixed at 40 minutes, but some climates do not allow such long exposures (Baillaud 1929). Some astronomers were skeptical of the possibility of following all the rules. Henry Andoyer, from Toulouse in France, preferred to call upon “the experiment of the observer” (Baillaud 1891). He estimated that the daily experience with the instrument enabled him to develop a more adequate know-how (.). George Rayet, director of the observatory of Bordeaux in France, recognized that certain, theoretical considerations for the measurement of stars’ positions “*impracticable in the reality of the things*” (Rayet 1901). There was thus a strong tension between a system of standards and local and individual characteristics. The organizers of the Carte du Ciel became aware of the danger of maintaining rules that were too strict and limiting. Felix Tisserand, director of Paris Observatory in 1895, recognized that “to want to do best, one is sometimes likely to miss the good” (*Bulletin* 1895). Ernest Mouchez and David Gill set up a policy of flexibility.. This implied easing the rules and the standards by taking into account individual situations. Two forums for dialog, distinct but complementary, opened then for the participants of the Carte du Ciel.

The first is related to the international conferences. Initially, they were not supposed to reconsider a decision. But in 1890, Ernest Mouchez recognized that it was not a question of an “absolute law” (*Bulletin* 1892). It is possible to revise one of the inapplicable or too complexes rules. Thus, in a meeting of 1891, several astronomers disputed a resolution which envisaged to make only one exposure for the photography (Trépiéd 1892). envisaged making only one exposure for each area. They proposed making three exposures, which make it possible to locate more easily false stars. The discussion was animated. Certain astronomers maintained that the risks of confusion were great for the very rich areas of the sky. Agreement seemed impossible. A technical commission was appointed. It proposed to preserve the single exposure and to study, in certain observatories, three exposures. The Conferences became a Parliament of the Carte du ciel, in

which confrontations and debates were numerous. It is a question of seeking a democratic consensus thanks to a collective work of negotiation.

4. The circulation of opinions

The *Bulletin of the Permanent International Committee for the photographic execution of the Carte du Ciel* was the second forum for dialog, which appeared in the years 1890. I would like to describe in detail its role and its contents. The first volume was published in 1892. In the introduction, Ernest Mouchez specified that the *Bulletin* must contain information useful for the astronomers taking part in the *Carte du Ciel* (*Bulletin* 1892). A section of the *Bulletin* was devoted to the correspondence. It gathers the mails of the astronomers concerning their practical remarks or their difficulties. Mouchez ensured that the discussions were always open and that the objective was to obtain “a final general opinion (...)” (*Bulletin* 1895). The *Bulletin* disseminated information and discussions in order to obtain a broad agreement among the astronomers. It supplemented the work of the international Conferences.

We can distinguish three large sets of themes in the first *Bulletins* of the *Carte du Ciel*.

The first relates to the examination of the instruments received to take photographs. The astronomers conducted tests then gave accounts of their results in the *Bulletin*. In 1888 Franz Renz (of the Pulkovo observatory) inspected the photographic plates of Paul and Prosper Henry. He recognized the quality of the material which met the desired precision (*Bulletin* 1892). In the same manner, the astronomers described their first experiments with the camera. Charles Trépied, director of the Algiers observatory, ensured, in 1891, that after four months of use and tests, the photographic equatorial functioned well (*Bulletin* 1892). Among the technical studies, the comparisons between materials played an important part. For example, the astronomers devoted considerable time to the collective evaluation of the screens intended for the calibration of the image sizes. The various points of view and technical tests made it possible to obtain a consensus and to better determine the limits of the instruments. The exchanges with the manufacturers were also important to understand operation of the equipment or to prevent possible practical difficulties. The *Bulletin* transcribed these discussions between scientists and manufacturers. Hermann Vogel, director of the observatory of Potsdam, wrote a letter in July 1890, about the *reseau* which made it possible to locate the position of stars. He noticed in particular that a too much pressure on the plates from the *reseau* between the photographic plates and the *reseau* involves important misreadings (*Bulletin* 1892). The French manufacturer Paul Gautier, in charge of the construction of the *reseau*, answered Vogel in the *Bulletin* of the *Carte du Ciel*. He explained why the frame that he had envisaged took into account the characteristic of the plates (*Bulletin* 1892). Those were not simply fixed, which avoids too strong tensions on glass.

The second topic which one finds in the *Bulletin* relates to the division of the experiments. The astronomers described their difficulties, the problems which they encountered and concrete solutions that they implemented. In 1895, the *Bulletin* published several remarks in connection with the *reseau* which had a very fragile layer of silver. Layer became uneven at certain places, which could create false stars on the photographic plate. The *Bulletin* gave the method adopted by the majority of the astronomers: the regular use of a brush to remove stars (*Bulletin* 1895). These exchanges made it possible to understand the limits of the rules fixed at the beginning. From the same point of view, the *Bulletin* revealed the differences in methods between countries. Thus, concerning the scale of the sizes of the star images, resulted in a difference of opinion between the French and Finnish astronomers. The first used a single multiplying coefficient between the exposure

time and the size of stars (*Bulletin* 1895). The others, on the contrary, gradually made this coefficient vary according to the size of stars (*Bulletin* 1895). Each presented his arguments by publishing long reports in the *Bulletin*. The French astronomers considered the method used by the Finns to be not very reliable (*Bulletin* 1895). The *Bulletin* allowed a greater circulation of the experiments and methods. It obliged the astronomers to detail their practices and to compare them with those their colleagues. It started an international discussion on the manners of observing and of using photography in astronomy.

The third important topic that one finds in the *Bulletins* deals with the rules considered to be too constraining. Certain astronomers clearly acknowledged that they did not follow the resolutions of the Conferences. Robert Ellery, director of the observatory of Melbourne, explained that he did not take photographs each evening, as requested (*Bulletin* 1895). The sky of Melbourne is too variable to allow such a great regularity. The resolutions voted in the Conferences were sometimes called into question. David Gill thus recognized in 1892, that it is perhaps not necessary to require fixed exposure times. It is possible to trust the observer. His experiment will enable him to judge (according to the transparency of the atmosphere, of the stability of the images and the sensitivity of the plates), the appropriate exposure time (*Bulletin* 1895). The know-how of the astronomers replaced sometimes the initial rules. Desired uniformity threatened, in the long term, the realization of the *Carte du Ciel*. Too many constraints and requirements could paralyze the project. The organizers accepted thus that each observatory has its own measuring machine for the plates. Certain astronomers will use machines allowing for faster but less precise measurements. The important thing for the organizers, was that the various techniques were properly documented.

The *Bulletin of the Permanent International Committee for the photographic execution of the Carte du Ciel* was the effective means to adjust practices. It makes it possible to coordinate activities. In particular it made it possible to correct the system when it was too rigid. The circulation of the memoirs and letters transformed the scientific practices in all observatories. The technical remarks, the different scientific traditions according to country, the concrete solutions all appeared in the *Bulletin*. It was used to negotiate and build collective rules of work.

5. Conclusion

The beginnings of the *Carte du Ciel* were marked by an important transformation in the organization of scientific activity. The organizers of the *Carte du Ciel* imposed initially a very strict system of rules to coordinate work of all the observatories. This step is characteristic of the regime of knowledge which was set up in the West in the years 1870. The observatories were scientific factories. The industrial model was characterized by the division of labor and the and the standardization of instruments. With regard to the *Carte du Ciel*, this scientific policy quickly became ineffective due to differences between observers and local observing conditions. The organizers of the *Carte du Ciel* modified the rules of the work. Two forums of dialog developed : the international Conferences and the *Bulletin of the Permanent International Committee for the photographic execution of the Carte du Ciel*. They made it possible to find a balance between the universal standard and the local practices. The adjustment of the practices is initially a collective work of negotiation.

In conclusion, I want to propose an explanation for the radical transformation of the diffusion process of the rules and conventions within the framework of the *Carte du Ciel*. Several studies of history of sciences, namely those of Vernant (1988), D  tienne (1965),

Biagioli (1995), Shapin & Schaffer (1993), underlined the powerful bond which links a mode of political organization at a precise moment and conventions which govern the scientific community and its practices at that time.

In the case of the Carte du Ciel, the astronomers are careful to underline the major role of France in the project. In 1887, Otto Struve, the director of Pulkovo observatory, recognized that the initiative of the project was entirely that of France (Baillaud (1929)). The French political authorities required on their side, as expressed by Louis Liard, director of the higher education in the the Ministry of education, that France play a major part in the scientific project (Liard 1886). One can link this insistence to underline the eminent place of France, to the emergence of a new political regime which was set up with the third republic. The Parliament was at the center of the democratic system (Berstein & Milza 1996). At the same time, the laws on press freedom allowed the expression and the circulation of opinions and ideas (Terrou 1972).

The Carte du ciel is marked by the French, republican and liberal political regime, which emerged after 1870. For the political world as for the scientific world, the research of the consensus passed by the installation of democratic rules and the possibility of a free expression.

However, the originality of the project of the Carte du ciel lies less in the convergence of the political and scientific forms of organization, that in the will of the French scientific community to diffuse on a world scale the new principles of government, set up by the republican system. The Carte du ciel constitutes from this point of view, for France, a first experiment in the propagation of a model of research organization.

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