T.N. THIELE AND THE CARTE DU CIEL

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ABSTRACT. T.N. Thiele participated in the astrographic conference in Paris 1887 and was the first theoretician to reduce and analyse the photographic plates of the Henry brothers. He was an enthusiastic supporter of photographic astrometry because of its elimination of personal errors. However, for different reasons he did not want the Copenhagen Observatory to take responsibility for a Carte du Ciel zone. Thiele's life and work and his plans for the development of astrometry are presented.

At the international astrographic congress in Paris 1887 were two Danish delegates: the director of the Copenhagen University Observatory, Professor T.N. Thiele (T) and his observer C.-F. Pechüle. We shall give a short description of the life and work of T and his contribution to "Carte du Ciel" at its initial stage, and explain why he, despite being an enthusiastic supporter of photography, would not take responsibility for a zone.

Thorvald Nicolai Thiele (1838-1910) was from his youth interested in applied mathematics for which reason he chose the study of astronomy. He worked on the computation of orbits of double stars and discussed especially the great systematic differences between different series of observations. An eye disease made him conscious of personal errors and the theory of errors should become his main subject and lifelong occupation. He criticized O. Struve's attempts to determine personal errors by artificial double stars (1) and concluded (2, p. 10) that the great work "was nearly wasted and could hardly be saved for science".

In the textbook "Theory of Observations" (3) T demonstrates a profound insight in the subject and gives an original justification of the principle of least squares by his concept of "free functions" which greatly extend its domain of applicability. To describe general probability functions, T introduced the concept of "cumulants" (Hald 1981). His books were, unfortunately, not so widely read as they deserved; some (Hald 1981, p. 5) find his style rather difficult to understand, but Newcomb (1906, p. 84) finds it "a very clear presentation of the subject of errors of observation".

Thiele's interpolation formula (Abramowitz 1970, formula 25.2.50) gives expansions in continued fractions by reciprocal differences. T did

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extensive works (4) on the approximations of spectral series by rational, Balmer-type functions. An example of his mastering the art of numerical methods is the brilliant idea (5) to dispense with the cumbersome computations of orbital elements for newly discovered asteroids. It is assumed that the planets move on a heliocentric sphere with the adopted radius 2.8 astron. units. The spherical coordinates on this sphere would become smooth enough to permit ordinary Newton interpolation. For orbits with small eccentricities and semi-major axes near the adopted mean radius the method is exact, but in most other cases accurate enough for the computation of the search ephemerides during the discovery opposition.

T was co-founder and actuary of a life insurance company (the only one with a named asteroid: (362) Havnia) and made original contributions to the problems of premium reserves and mortality tables.

All kinds of numerical data interested T and at a time with no parlamentary government, votings and elections were vividly debated subjects on which he wrote some papers. T regarded (6) the number of votes an estimate of an objective internal quality of the proposals or candidates A, B, C, ... If the number of votes of A over B is denoted (A-B) then we should have equations of conditions like: (A-B)=(A-C) +(C-B). A number of votings in excess of the minimum number should be secured and adjusted by least squares. Mean errors could then be ascribed to all results as a safeguard against decisions which were not statistically significant. If the issue were, say, the weights of the candidates, these methods would undoubtedly improve the results, but different voters will often see different qualities and he could not foresee that voting could become a new instrument of power. Besides, voting is rarely "free" in his own sense of the word meaning statistically independent; information by a few opinion leaders - the number of which is becoming fewer and fewer with the modern mass communications - may be a source of systematic errors and his optimistic belief that truth will be achieved in the limit of an infinity of voters, can no longer be maintained.

Already in 1881 T made photographic experiments with a 10 cm lens (P. Darnell, private communication) and he made the first thorough analysis of the accuracy of photographic positions. Just before the 1887 congress he measured, at the Paris Observatory, 3 plates with 3 exposures by Paul and Prosper Henry. From repeated measurements of 22 stars, he gave a formula (7) for the mean error as a function of the number of pointings, exposures, plates, magnitude and distance from the centre; at the centre the mean error was of order $\pm 0''.1$ and at 1° distance $\pm 0''.3$. He remarks: "The most serious difficulties which we shall find will, perhaps, result from a want of sufficiently exact observations of fundamental stars". He welcomes the subjectivity of the observer being substituted by the objectivity of the plates and concludes: "that our observatories should replace, as soon as possible, their great micrometer-refractors and heliometers by photographic telescopes of long focal distance". The latter remark was noticed especially by Pechüle who feared an interruption of his visual work and complained in letters (8) to the ministry, - this resulted in cool relations between the director and his first observer.

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On April 20 T opened the meeting by pointing out the necessity of having <u>four</u> stars with known positions on each plate. This was not obvious, for apparently two stars would suffice to provide the orientation and scale of a plate. However, T repeated his statement and expressed his doubts with respect to the accuracy by the use of a "rèseau" (9, pp. 53, 60, 62).

T did not want the Copenhagen Observatory to take the responsibility for the observations of a zone, - and he had a good excuse: The observatory was being increasingly encircled by the city and light and smoke prevented that faint objects could longer be observed!

T's personal interest was not surveys but to achieve the highest possible accuracies and he may have feared that he would get little assistance to the routine work he disliked (Burrau 1911). Instead, he planned precise observations of bright objects and believed that he should contribute more to the development of photographic astrometry by procuring an instrument, which was different from the several normal astrographs. A planned railway nearby could, however, make precise observations impossible and a removal of the observatory into the country was considered. T called attention to some advantages by staying near the university and a big city but found a second observatory useful; he even mentioned as a possibility (8) a branch at the West Indies, where St. Thomas and St. Croix were Danish colonies and at which experience was available from a temporary observatory for the observation of the transit of Venus in 1882. The outcome was, however, a new double-refractor with a 20 cm photographic lens and f=480 cm at the old site.

T's plans for the new instrument are revealed in his principal speech (2) at an annual festival for the Reformation (of the church by Luther), where he spoke about the present reformation in observing astronomy by the use of impersonal methods. First of all he mentions photography but also Repsold's impersonal micrometer (he constructed himself a micrometer, see Winterhalter 1889, p. 213) would put an end to the personal errors. With the new double-refractor he would obtain precise relative positions for planets and satellites and said that: "It is my intention to select some areas in the ecliptic with bright stars and then photograph these places when passed by planets or bright asteroids. So the minor planets, from being a nuisance, could instead be useful. With precise computations of orbits, these selected areas would then be strongly tied together and provide an independent check of the positions of fundamental stars". This programme could not have failed to give important contributions to astrometry. Few years later the very confusing situation arose with respect to the fundamental star positions due to the extreme $\Delta\delta_\delta$-errors which was solved only after long time and big efforts (Schmeidler, 1952). The proposed planet observations would have provided a rather precise equator point by Newcomb's (1895, §45) technique. However, the great visions were not realized. Hampered by his eye desease, T could not observe himself - sometimes not even read - and despite his great intellectual capacity, he could not have managed to do everything. Small appropriations to students' help by routine computations were refused (Nielsen 1961). Budgeted expenditures for assistance were of the order of 500 Kr./year, - less than the 600 Kr/year for keeping two horses. Economy was practiced to an extent which made it

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impossible to ripe the fruits of the main investments in instruments and capacity of work.

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Discussion:

WORLEY Thiele made two important contributions to double star astronomy. First, there was his suggestion which eventually evolved into the Thiele-Innes-van den Bos method of computing ephemerides of visual double stars. This method greatly simplified such computations. Second, he was the first person to employ ocular enlargement in the photography of double stars.