PULKOVO OBSERVATORY AND THE NATIONAL OBSERVATORY MOVEMENT: AN HISTORICAL OVERVIEW

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ABSTRACT: The patronage of national governments has played an important role in the history of astronomy, classically in the form of National Observatories. In this paper we 1) argue that the last three centuries have seen what we may call a "national observatory movement," in that national governments during this period increasingly supported astronomical observatories, and in that such institutions share certain common properties of origin, purpose and evolution; 2) demonstrate the important role that Pulkovo Observatory has played in this movement; and 3) compare certain aspects of the Pulkovo Observatory and the United States Naval Observatory as exemplars of this species founded within a decade of each other under very different political conditions.

1. The National Observatory Movement

The phrase "national observatory movement" implies an ongoing process with definite goals shared by members of the national observatory community. The term has been applied before to attempts to form national observatories within particular countries, such as the United States (Paullin, 1923) and India (Ansari, 1985), but we apply it here in a more encompassing global sense, where the national observatories of particular nations are seen as members of the movement. We may consider that this broader process began, after the important but abortive founding of Tycho Brahe's observatory by Frederick II of Denmark in 1576, with the Paris Observatory (1667) and the Royal Observatory at Greenwich (1675). But the need for national observatories did not end in France and England. As Table 1 shows, Germany and Imperial Russia added two important examples in the early 18th century, the rate of new institutions actually increased in the 19th century, and new members have continued to be added in the 20th century. It is clear that all national observatories are not listed in Table I, particularly those of the Far East. A more comprehensive list would be an interesting and major task, but the sample given here is large enough to demonstrate several points and the overall benefits of this institutional approach to the history of astronomy. It should also be clear that there are many other "astronomical centers of the world" (Krisciunas, 1988) that may receive partial government funding but are not considered national observatories.

We may distinguish three eras in this movement: the *first era*, in which the prototype Paris, Greenwich, Berlin and St. Petersburg observatories were founded; the *second era*, characterized by offshoots from previous national observatories (Royal Observatory Cape), by new observatories of younger nations (USNO), and by the rise of astrophysical observatories; and the *third era*, post World

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War II, characterized by national or international consortia, large budgets relative to the previous eras, and the study of old and new wavelength regions with increasingly sophisticated telescopes, detectors and spacecraft. National Observatories were the original "big science" of their time, but in this third era, which encompasses both the Computer Age and the Space Age, the movement has benefited from the general trend toward even bigger science seen in the national laboratories of many disciplines (Price, 1963; Weinberg, 1967).

Table 1. Some Important National Observatories and Their Patrons

	Institution	founded *	patron
	Uraniborg (Tycho Brahe)	1576 (abortive)	Frederick II
	Paris Observatory	1667	Louis XIV
1st	Royal Observatory, Greenwich	1675	Charles II
Era	Berlin Observatory	1701	Frederick I
	St. Petersburg Observatory	1725	Peter the Great
	Royal Observatory, Cape	1820	Britain
	U. S. Naval Observatory	1830	U.S. Navy
	Pulkovo Observatory	1839	Nicholas I
	Chilean National Observatory	1852	Chile
2nd	Argentine National Observatory	1870	Argentina
Era	Potsdam Astrophysical	1874	German Acad. Science
	Smithsonian Astrophysical	1891	Smithsonian/ U.S.
	Dominion Observatory	1903	Canada
	Dominion Astrophysical	1918	Canada
3rd	NRAO (U. S.)	1956	NSF/AUI
Era	Kitt Peak	1957	NSF/AURA
	NRAO (Australia)	1959	CSIRO
	Cerro-Tololo Inter-American	1963	NSF/AURA/Chile
	European Southern Observatory	1964	5 countries (now 8)
	Anglo-Australian (Siding Spring)	1967	Britain/Australia
	Space Telescope Science Institute	1981	NASA/AURA

* A number of criteria can be used for founding dates. The majority of dates here indicate when funding was assured. Abbreviations: AUI (Associated Universities, Inc.), AURA (Association of Universities for Research in Astronomy), CSIRO (Commonwealth Scientific and Industrial Research Organization), NASA (National Aeronautics and Space Administration), NSF (National Science Foundation), NRAO (National Radio Astronomy Observatory).

Aside from the striking association of all the early institutions with their national scientific

societies (whether Academies of Science or the Royal Society), the common property that stands out in the first era is the largely practical nature of the work for which the first national observatories were founded. Whether for the improvement of navigation, geographic and geodetic work, or calendar reform, all these institutions were founded to meet a national need. In meeting these national needs the precise determinations of celestial positions formed the backbone of much of their work; for example, the method of lunar distances for navigation required precise ephemerides of the Moon and precise positions of stars as the reference frame, a task that was brought to fruition only with Maskelyne's publication of the British *Nautical Almanac* in 1766 (Sadler, 1976). Byproducts of this practical work were the great star catalogues of Flamsteed and others, Bradley's discovery of aberration of light, the determination of proper motions, and many other results also of interest to pure astronomy.

The early institutions of the second era were also founded for similar purposes, but now with the determination of longitude by chronometers as the most promising method of navigation at sea, and an important method for determining geographical positions as well. With accuracies now on the order of tenths of arcseconds *vs.* about 15 arcseconds for Flamsteed (Chapman, 1983) greatly improved star catalogues were the byproducts of the Cape, U. S. Naval, Pulkovo, Chilean and Argentine observatories, whereas in this era of improved instruments stellar parallaxes too were at last possible. With the rise of the astrophysical national observatories at the end of the 19th century, results beyond any practical need were the goal, and the question of how far public money should support such research became increasingly important. The very existence of the third era gives an answer to that question, for the research of these observatories has gone beyond anything that the public would consider practical. The longevity of the older institutions, as well as the occasional addition of new ones, attests to a continuing national necessity, though one expanded to include the benefits of pure research, whether to national prestige or the advancement of astronomy.

A second common characteristic of national observatories, rooted in the first property of common purpose in the service of a perceived national necessity, is that most of them at the time of their founding undertook similar programs in order to carry out their tasks. This led to substantial interactions and cooperation among national observatories, not only in international programs such as the transits of Venus, the *Carte du Ciel*, the Eros campaign and long-term astrometric projects such as the AGK3R and Southern Reference Star systems, but also in many colorful episodes in the history of astronomy. A notable example of the latter is the involvement of the observatories of Paris, Greenwich and Berlin in the discovery of Neptune. Of particular interest to this meeting, the work of determining fundamental reference frames has largely fallen to these national observatories, for few other observatories can undertake such long-term programs.

National Observatories have also faced in turn many similar problems and issues: the proper balance between practical and pure research, the relative roles of astrometry and astrophysics, the most efficient mode of administration, and patterns of funding, to name only a few. It is true that all astronomical institutions share to some extent these problems, but government institutions, particularly in regard to a mission to be accomplished, share them in peculiar and related forms.

Finally, it is notable that national observatories have historically been perceived as a distinct group of astronomical institutions, both by the institutions themselves and externally. Aside from cooperative programs, the younger national observatories such as Pulkovo and USNO often consulted their predecessors regarding buildings, instrumentation, and programs; visits and comparisons were often made among the national observatories to improve efficiency; and moral support was given in times of crisis such as threats of retrenchment or even abolishment. For all their similarities, each observatory has developed its own character, as it has met these problems and challenges in different ways. Even with obvious differences reflecting national styles, a global view

of the history of astronomy shows that national observatories, with their common purpose, common programs and common problems, form a distinct group of institutions and comprise a worldwide national observatory movement.

2. The Place of Pulkovo Observatory

Let me proceed to the second point, namely the role of Pulkovo Observatory in this movement. We note first from Table 1 that Pulkovo Observatory was founded in what we have called the second era of national observatories. By the 1830s the older national observatories were in many ways in their prime. In 1835 G.B. Airy began his tenure of almost a half century as Astronomer Royal at RGO (Meadows, 1975). At Paris Observatory the reign of Delambre was over, Alexis Bouvard had been Director since 1822, and Arago and Leverrier were coming on stage (Debarbat, Grillot and Levy, 1984). In Berlin J. F. Encke was well into his long tenure at a revitalized observatory newly constructed in 1828 (Dick, 1951).

In Russia itself, the St. Petersburg Observatory was now in a run-down condition, and its demise figured directly in the founding of Pulkovo Observatory. Like the Berlin Observatory a few years earlier Pulkovo thus began with new buildings and instruments on a new site, but unlike Berlin it also began with a new head, Wilhelm Struve, who as the head of the Dorpat Observatory in Tartu had completely outdone the St. Petersburg Observatory. Struve relates how in December, 1830 he frankly told Tsar Nicholas I of the sad condition of the St. Petersburg observatory. The result was the Tsar's decision to build an observatory near the capital, to be located on the hill of Pulkovo, outside the city. The details of Pulkovo's founding, and the life and work of the Struves, are by now well-known, thanks to Struve's 1845 *Description*, and more recently the work of Daedev (1972) and Sokolovskaya (1976) in Russia, and Krisciunas (1978, 1988) and Batten (1988) in the U. S. and Canada. For the record I show in Table 2 some of the more important dates in the founding of Pulkovo, taken from Struve.

Table 2. Important Dates in Pulkovo's Early History

1830	December. Struve meets with Nicholas I.
1833	October 28. Nicholas orders purchase of instruments
1834	February 24. Architects present their plans to the Commission
1834	April 15/3. Nicholas names Struve Director
1834	June-October. Struve's trip abroad to purchase instruments
1835	3 July/21 June. Foundation stone laid.
1839	August 19/7. Official inauguration
1845	Struve's *Description* published.

Source: Struve (1845). Double dates represent New Style/Old Style.

Pulkovo was one of the few observatories to have so many interests so early in its career. The official statute for the observatory specified not only the perfection of navigation and geographical positions, but also the advancement of astronomy beyond any practical need. While it is clear that

Struve took seriously the practical aspects of his job, his contributions to the advancement of astronomy are even better known. The breadth of interest and the development of the work at Pulkovo in its first 50 years may be seen from Table 3, according to categories established by Struve himself.

We see from this table that the work of the Pulkovo Observatory during its first 50 years was dominated by sidereal and solar system studies, some of which contrasted with the more purely practical work such as the measure of the arc of the meridian. The stellar work included double stars, parallaxes, positional catalogues and the constants of precession, aberration and nutation; and the planetary work consisted largely of comets, satellites and eclipses. As a member of the second era of national observatories, its practical problems of navigation and geodesy were more refined than the problems that faced its older predecessors at their founding. The chronometer method, rather than the method of lunar distances, was on the ascendancy, with all that implied not only for navigation but also for geographic positions by chronometer expeditions, the latter for which Pulkovo is famous. We also note from this table the early entry of Pulkovo into the realm of astrophysics; from 1864 to 1888 10% of the publications dealt with astrophysics, while the number of geodesic and geographic publications declined by half relative to the first 25 years.

Table 3. Research Publications at Pulkovo, 1839–88

Subject	1839–64		1864–89		Differences
sidereal	49	30%	63	27%	–3
solar system	42	26%	54	23%	–3
practical astronomy	14	9%	21	9%	0
geodesy and geographical positions	36	22%	22	9%	–13
history, bibliography & physical experiments	22	14%	33	14%	0
astrophysics	0		23	10%	+10
mathematics, physics & theoretical studies			21	9	+ 9

Sources: Struve (1865) and Pulkovo Observatory (1889)

Pulkovo Observatory quickly became legendary among national observatories. Early visitors to the observatory, such as the Astronomer Royal George B. Airy, and the American astronomers B.A. Gould (1849) and C. Abbe (1868), left fascinating accounts of their visits. On his return from St. Petersburg in 1847, Airy typically remarked that "... no astronomer can feel himself perfectly acquainted with modern observing astronomy in its most highly cultivated form, whether as regards the personal establishment, the preparation of the buildings, the selection and construction of the instruments, or the delicacy of using them, who has not well studied the Observatory of Pulkowa," (Airy, 1848). This is high praise indeed coming from the head of another national observatory,

especially one with the personality of George Airy. In Russian history of science Pulkovo represents a revitalization of government support for astronomy in that country; in the international sense it represents the addition to the community of national observatories that quickly became a model for the others.

3. Pulkovo Observatory and the United States Naval Observatory

The detailed comparative history of astronomical institutions, especially those in a similar class such as national observatories, is an important task. It is, however, a very large one that cannot be carried out in this paper, and that indeed cannot be carried out fully until the individual histories of these institutions are written. But I would like to touch here on a more manageable task — the comparison of USNO and Pulkovo in just a few areas during their first 50 years, as two exemplars founded very close together in time, though very far in political systems. This comparison will serve to illustrate some of the similarities and differences, some of the variations on the theme of national observatories.

We may briefly compare the two institutions in four areas during the first half century of their lives: Origin, administration, instruments, and programs. I will conclude with some remarks on 20th century political effects on these institutions.

3.1. Origins

Whereas as we have seen in Russia, Nicholas I was convinced of the need for a new observatory, and his wishes were of course carried out, in the United States President John Quincy Adams had called for such an observatory in 1825, but it was expressly forbidden by Congress as a waste of money. There were advantages to having a czar if he happened to be on your side. Thus in November, 1830 it was left for a lowly Navy Lieutenant to recommend to the Secretary of the Navy that a Depot of Charts and Instruments be founded in Washington, D.C. This direct forerunner to the Naval Observatory was established in December, 1830, the very same month that Struve had his audience with Nicholas I. It was founded to care for navigational instruments and to rate chronometers by astronomical observation, and here was the opening to astronomy. It thus had only very modest astronomical instruments, and was not yet an observatory in the true sense of the word.

The founding of Pulkovo Observatory in 1839 did not go unnoticed in the United States. John Quincy Adams, now an ex-president, pointed out to Congress a few months later "Here is the sovereign of the mightiest empire and the most absolute government upon earth, ruling over a land of serfs, gathering a radiance of glory around his throne by founding and endowing the most costly and most complete establishment for astronomical observation on the face of the earth... The committee of the House [of Representatives] ... in casting their eyes around over the whole length and breadth of their native land, must blush to acknowledge that not a single edifice deserving the name of an astronomical observatory is to be seen" (Rhees, 1879).

Though Adams' arguments were to no avail, another Navy Lieutenant, James M. Gilliss, officer-in-charge of the Depot of Charts and Instruments, pushed through Congress a bill for a new Depot in 1842, which became a national observatory in fact if not yet in name. The purposes of founding for both Pulkovo and USNO were thus similar, but the purpose of the USNO was more limited at first, with the determination of geographical positions being left to the Army and the Coast Survey and a role for less practical aspects of astronomy only gradually evolving (Dick, 1980).

3.2. Administration

Whereas Pulkovo was founded by Royal decree and came under its country's Academy of Sciences, the U. S. Naval Observatory was totally under the control of the Navy, and headed at first by Navy Lieutenants and later Navy Captains or Admirals. While the distinguished astronomer Struve brought instant fame to Pulkovo Observatory, the Naval Observatory was at first better known for Matthew Maury's oceanographic wind and current charts than for its astronomy. This illustrates an important point: that even though national observatories are bound to carry out certain specific duties necessary for national needs, the character of the institution can be largely shaped by the personality and interests of its Director and senior staff, in addition to the overriding importance of its original charter and administrative sponsor. In the United States it is perhaps not surprising that oceanography rather than astronomy dominated the observatory's first 20 years; there were as yet no distinguished astronomers in the country, indeed no tradition of astronomy to draw on as there was in Russia. Only in the post-civil war era, with the names of Newcomb, Hall, Harkness and G.W. Hill, did the Naval Observatory achieve fame in astronomy.

3.3. Instruments

In 1834 Struve journeyed to Europe to obtain instruments, and in 1842 Lt. Gilliss made a similar journey.

Table 4. Early Instruments at Pulkovo and USNO

Pulkovo (1839)	USNO (1844)
15-inch achromatic refractor (Merz and Mahler, Munich)	9.6-inch achromatic refractor (Merz and Mahler, Munich)
heliometer (Merz and Mahler)	
small parallactic refractor	
two comet seekers (Merz and Mahler)	3.9-inch comet seeker (Merz and Mahler)
large meridian telescope (Ertel)	5.5-inch transit instrument (Ertel)
large vertical circle (Ertel)	
large meridian circle (Repsold)	4-inch mural circle (Troughton & Simms)
prime vertical transit (Repsold)	5-inch prime vertical transit (Pistor & Martins

As Table 4 shows, both turned to the expert instrument makers of Europe, and their choices are an interesting testimony to the rise of the German astronomical technology as opposed to the English. Both obtained transit instruments from the German makers Ertel (successor to Reichenbach at Munich). Both obtained achromatic refractors and comet seekers from Merz and Mahler (successor to Fraunhofer at Munich). Struve opted for a Repsold prime vertical transit instrument and Gilliss for a Pistor and Martins from Berlin. Whereas Merz and Mahler made a 15-inch refractor for Struve, Gilliss could only afford a 9.6 inch, exactly similar to the Dorpat telescope Struve had previously used. Only with the mural circle did Gilliss show some faith in English instrument makers; Struve showed none.

Though the U. S. Naval Observatory began with a relatively small achromatic refractor, it is notable that by 1873, American technology had advanced to the extent that the Naval Observatory had the Alvan Clark 26-inch refractor, the largest in the world. In another example of direct interaction between the two observatories, Otto and Hermann Struve visited the U. S. in 1879, where Newcomb persuaded them to purchase from Alvan Clark the 30-inch lens for their new refractor. This turnabout over a period of 30 years is testimony the rapid rise of astronomy, and astronomical technology, in America.

3.4. Programs

Like Pulkovo the Naval Observatory carried on long-term programs for star catalogues, double stars and specialized observations, leading in some cases to direct cooperation, most recently in the form of the Southern Reference Star (SRS) catalogue. If we were to categorize publications at the USNO by subject over its first 50 years, similar to Table 3, a larger proportion of practical work would be evident at the Naval Observatory, again due largely to Maury.

Unlike Pulkovo, where we have seen in Table 3 a substantial amount of research in astrophysics by 1888, the Naval Observatory did not undertake a sustained program in astrophysics until John Hall's work on interstellar polarization beginning in 1948. The difference lies partly in a more restricted concept of mission at the USNO, but also in individual differences — whereas Struve pushed astrophysics at Pulkovo beginning in 1866, Newcomb in the 1890s was still questioning its importance. With the founding of the Smithsonian Astrophysical Observatory in the 1890s, the USNO left the subject to such specialized observatories, or to university or privately endowed observatories such as Lick, at least until in the 20th century the close relationship between astrometry and astrophysics became evident.

3.5 Political Events

It is clear that both Pulkovo and the U.S. Naval Observatory have been subject to political and economic events in their own countries. The 1930s was a particular time of crisis for both observatories. In the United States in 1932 President Herbert Hoover, as part of his policy to counter the Great Depression, recommended that the Naval Observatory be transferred from the Navy to the Commerce Department, a proposal seriously considered by Congress, but not carried out. Hardly had this crisis been weathered when President Roosevelt came into office and proposed abolishing the Naval Observatory completely in a money-saving move, a proposal obviously also not carried out.

In the Soviet Union the situation for Pulkovo Observatory during the same decade was even more serious. Not only were the threats more serious, they were followed by action, as Pulkovo Observatory was caught up in Stalin's purge of Soviet astronomers in 1936-37. Throughout the Soviet Union 29 astronomers were arrested, many never heard from again. At Pulkovo alone 13 scientists, almost half the staff, disappeared during these years. This tragic event has recently been studied in detail by Robert McCutcheon (1989). Nor did this end the problems of Pulkovo Observatory ; it was completely destroyed in 1942 during the war. With all of its scientific achievements, we should not forget that the very existence of the Pulkovo Observatory today is a testimony to endurance and hope.

4. Summary and Conclusion

Many more comparisons could be made, but these examples suffice to indicate some of the interesting problems that arise in the comparative history of that subset of astronomical institutions known as "national observatories".

In summary, looking back on the last three centuries we may conclude that national observatories as a group do indeed represent a related process responding to the needs of each nation; that Pulkovo arose suddenly like a bright star in this movement due largely to the Struves, who not only filled a national need but also greatly advanced astronomy; and that despite their similarities, national observatories may evolve in quite different ways, as a result of political systems, science organization, and individual enterprise, as shown in the case of Pulkovo and its American counterpart.

It is clear that over the centuries national observatories have achieved many of their goals, perhaps too well. Navigation and other practical needs are no longer the driving force for many of them, and most have changed in ways their founders could have hardly forseen. The Berlin Observatory has gone through many reincarnations, Cape Observatory was amalgamated with others, and Greenwich Observatory is at present undergoing radical change.

Despite the appearance of new evolutionary forms in the movement, such as the multinational European Southern Observatory and the Space Telescope, these developments warn us that the future of the national observatory movement is not clear. Among astronomical institutions, national observatories especially face the problem of justifying their relevance to national needs. They must surely change, not only in advancing new techniques and instrumentation, but also in reshaping their goals to meet modern requirements. Just as surely, they are bound to be challenged about the relevance of any new goals to national needs, and affected by national priorities and economies much more directly than their colleagues at private institutions or universities. Perhaps the comparative study of the histories of these institutions will help to illuminate future directions, as well as past patterns. The roads taken will determine the fate of this venerable movement, now well into its fourth century, that has contributed so much to astronomy.

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Discussion

QUIJANO: The "Real Observatorio de la Armada en San Fernando" (Spain) was founded in 1753 as a naval observatory by King Fernando VI. The "Observatorio de Madrid" in Spain was founded as a national observatory at the end of the 18th century.

S. DICK: It is clear that I have not listed all national observatories in Table 1. This is only a sample, but I think a good sample, to demonstrate some patterns. Further research is needed to see how other national observatories fit into this scheme.