

The Social Life of Astronomy: Time-Reckoning, Agriculture, and Knowledge Systems in Pre-Colonial Kerala

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Abstract

Pre-colonial Kerala had a complex and well-developed astronomical tradition that pervaded everyday social, economic and cultural life. This article aims to address the nature of the interconnectedness of astronomy, agriculture and time-reckoning practices in pre-colonial Kerala prior to the establishment of modern colonial science structures. It traces the emergence and evolution of the Kollam Era, the operation of Panchangam traditions and the scientific developments and accomplishments of the Kerala School of Astronomy and Mathematics (e.g., through Madhava of Sangamagrama, Parameshvara, and Nilakantha Somayaji). The research aims to demonstrate the ways in which celestial observations and calendrical computations were employed for agricultural management, ritual performance and the organization of the administrative apparatus. The references are supported by epigraphical records, palm-leaf manuscripts and astronomical literature. This article argues that the pre-colonial Kerala's astronomy as a practical and cultural discipline was bound up with agricultural calendars and local observation systems that sustained the social structure. The research contribute to scholarship on the history of Indian science and the significance of indigenous epistemologies for historical processes by investigating its continuity through the modern age.

Keywords: Kerala School of Astronomy, Kollam Era, Panchangam, Agricultural Calendars, History of Science in Kerala.

Introduction

Kerala occupies a significant position while considering the deep rooted traditions in the field of astronomy, mathematics and calendrical calculation. A systematic methodology for time reckoning and astronomical observation influential for the functioning of both the agrarian and other aspects of the society was present in Kerala long before the onset of the colonial scientific traditions. The convergence and fusion of these different scholars brought about the existence of a unique scientific culture in Kerala. The physical environment of Kerala also had its due share in establishing this relation between astronomy and society. Since it depends largely on the seasonal monsoon patterns, timely prediction of weather phenomena was very crucial for it to regulate its agrarian and maritime activities efficiently. The astronomy that was observed at this place was not confined to intellectual circles, but also considered an essential part of human life. Kollam Era, Panchangam practices, temple-based astronomical procedures etc., played a crucial role in the ordering of economic and social life of Kerala. Farmers relied on

calendrical calculations to guide the timing of planting and harvesting. Ship masters and navigators consulted astronomical calculations in planning the far flung voyages across the Indian Ocean.

This contribution of Kerala reached the peak during the period between 14th to 17th century with the advent of the Kerala school of astronomy and mathematics to the credit of scholars like Madhava of Sangamagrama, Parameshvara, Nilakantha Somayaji and Jyesthadeva. Kerala astronomers fostered an intellectual tradition where observation and verification served as vital components for testing and refining existing scientific principles. It can be seen in the meticulous eclipse records by Parameshvara and from the works like Tantrasangraha by Nilakantha Somayaji. They managed to integrate scientific theoretical framework to their works and put them to practical use. They upheld the Indian systems of time reckoning and agricultural management along with the ritual aspects. It was also useful for long distant journeys through out the Indian Ocean as well.

Current studies address these mathematical achievements or calendrical systems separately in order to overcome the lacuna, the relation of astronomy and society, that existed in it. The article explores its existence and workings, the creation and development of Kollam Era, Role of Panchangam and works of Kerala astronomers etc. The research analyses why and how Astronomy worked as both a intellectual and practical force in Kerala. It offers valuable insights into the scientific past of Kerala and the importance of indigenous scientific endeavors in India.

Kollam Era (Malayalam Calendar)

The Kollam Era also known as Kollavarsham or the Malayalam calendar was one of the key elements in time-keeping practices in pre-modern Kerala. It was Originated from 825 C.E and was in use across Kerala for civil, religious and agricultural purposes for many years prior to the advent of colonial rule. It was a sidereal solar calendar and emphasized the sun's passage through the zodiac signs which is a notable divergence from the lunisolar calendars used in the rest of India. This sidereal solar calendar provided a steady base for tracking the seasons within Kerala's humid and monsoon-oriented environment. Scholarly inquiry often links its beginning to the thriving port of Kollam (formerly Quilon) which was a major center of trade and commerce during the period of the Chera and Venad rulers. One major theory connects it with the convening of an important meeting by King Kulashekhar Varman or to the rebuilding and fortifying of Kollam as a commercial center after its liberation from Chola domination by potentially involving the settlement of Persian Christians led by Maruwan Sapir Iso and trading guilds such as Anjuvannam. The introduction of this calendar standardized timekeeping throughout the region and marked a renewal and reinforcement of trade links with the Arab world and China. It can be seen in copper plate grants such as the Tharisappalli plates dated to 849 C.E. The earliest existing inscriptions of this calendar date to 973 C.E. (Kollam Era 149) and are in the form of a copper plate inscription found in Mampalli, issued by Sri Vallabhan Kotha or Sri Vallavan Goda of Venad. In this inscription recording the donation of a land to a temple, the specific phrase "Kollam Thontri Aandu" appears. This inscription bears witness to the swift incorporation of the calendar in administrative and religious affairs.

There are still several differing opinions among historians about the origin of the calendar. Some historians relating it to the construction of a temple or to the standardization of astronomical computations, while others associate it with various regional forms. The Malabar form centered in Calicut starts in mid-August while the Travancore form centered in Quilon commences late September, approximately a month later. The different start dates of these two forms of the calendar may have originated as a reflection of the fragmentation of Kerala into many individual swarupams and principalities. This calendar, in common

with other sidereal solar calendars, is composed of 12 months that derive their names from the names of the zodiacal signs. These twelve months are Chingam (Leo, starting mid-August to mid-September), Kanni (Virgo), Thulam (Libra), Vrischikam (Scorpio), Dhanu (Sagittarius), Makaram (Capricorn), Kumbham (Aquarius), Meenam (Pisces), Medam (Aries), Edavam (Taurus), Mithunam (Gemini) and Karkidakam (Cancer). It closely follows the sidereal year, which is of 365.256 days and has negligible adjustments for its long-term accuracy. It differs significantly from the lunar based systems which requires intercalation for adjustment by helping for greater accuracy.

This solar oriented calendar system had a profound influence on agrarian life in Kerala. For example, astronomical events such as the onset of the southwest monsoon in the month of mid-Edavam are indicated by Edavappathi and provide important markers for planting of paddy. The Virippu (first crop), Mundakan and Puncha crops also correspond to different planting and harvesting seasons, which correspond very accurately to the monsoon cycle required for cultivating wet rice as well as growing spice plantations. Numerous cultural and religious rituals in Kerala, such as the harvest festival of Onam in Chingam, associated with the legendary King Mahabali and the New Year in Medam (around April) associated with the auspicious alignments of celestial bodies in the sky. All these are intrinsically connected to the cycle of the year. Civil administration and other day-to-day activities in the state continued to use the calendar alongside and after the political ascendancy of the Venad rulers from the Perumals. Later records even indicate the continuation of its use with local variation. The reference to "Kollam Alintha Aandu" indicate the year according to this calendar after the year 1097 CE under the domination of the Chola rulers. The rare findings of some copper plate inscriptions and palm leaf manuscripts offer crucial information about the usage of the Kollam Era for noting down important astronomical phenomena like eclipses and celestial alignments and thereby helping scholars to critically study the existing Siddhanta texts. Although the Gregorian calendar also became widely adopted in 19th-century India during British rule, the Kollam Era continued in circulation. The Kollam Era was a distinctive local product of Kerala that was a unique blend of astronomy, trade and local governance that effectively served a purpose in every aspect of life-civil, religious and agricultural use.

Panchangam Traditions

Pre-modern Kerala Panchangam traditions were highly developed daily almanacs. They integrated the astronomical calculations with ritualistic, agrarian and socio-communal practices by synthesizing pan-Indian Siddhanta texts along with localized and observation-driven improvements. "Panchangam" itself describes the five elements that constitute an Indian calendar. It includes Tithi (lunar day), Vara (weekday), Nakshatra (lunar mansion), Yoga (angular sum of the Sun and Moon), and Karana (a fraction of a tithi). Kerala scholars stationed at temples and hereditary astronomer families (often Nambudiri Brahmins) calculated the elements with high accuracy over the generations. They corrected any discrepancies based on actual observations rather than reliance on pure textual prescriptions. A living tradition that merged Vakya methods (rule-of-thumb shortcuts found in ancient Siddhantas such as the Surya Siddhanta) with evolving Drik (observational) methods was the basis of the remarkably precise eclipse predictions and positional forecasts generated for predicting opportune times.

Some of the rare archaeological evidence in palm-leaf manuscripts kept at Kerala temples and illams (family properties) show detailed computation handbooks. They had the records providing parity corrections, refraction corrections and ayanamsa values appropriate for the latitude of Kerala (8-12N). Later scholars in the Kerala School of Astronomy and Mathematics built upon earlier calculation

traditions. The observations by Parameshvara on eclipses between 1395 and 1432 CE were made for decades and provided empirical data for correcting Panchangam computations. A century later, scholars like Nilakantha Somayaji formulated a sophisticated spherical trigonometry system for these calculations in the Tantrasangraha. It greatly enhanced the accuracy of the computation of tithis and nakshatras. Temple astronomers from centers of calculation in Kerala such as Tirur, Thrissur, and Thiruvananthapuram produced annual Panchangams for circulation throughout Kerala. It gives details about the community practices that ranged from determining astrologically favorable marriage times (by avoiding inauspicious yogas) to regulating daily pūjas. Nakshatra-based seasons provided specific dates for planting, for example rice transplantation was done at auspicious Rohini and Mrigashira nakshatras. The accurate eclipse and planetary predictions provided weather forecasts of a sort for flood-susceptible paddy fields. For Kerala's wet-rice and spice-based economy, specific Njattuvela periods (26 fixed pairs of Sun and nakshatra transits each lasting roughly a fortnight) were identified through the calendar. They were vital for the optimum timing of planting, weeding, and harvesting. It helped to minimize the risk of crop loss given bimodal monsoons. These traditions influenced even Kerala's seafaring and medical communities. Mariners used the celestial timings identified within the Panchangam to determine courses. The Ayurvedic treatments were synchronized with opportune karanas. Gurukula systems facilitated the transmission of these calculation skill through different generations. Rare annotated manuscripts that offer clues about calculation revisions based on empirical and predicted mismatches offer compelling evidence of a scientific orientation. Even by the eighteenth and nineteenth centuries, several families continued to produce locally adapted versions. Some of such observation produced after the establishment of observatories, incorporated European findings as well. The diversity in the computation methodologies of such Panchangam traditions is exemplified in the case of Pambu Panchangam, indicating the variations present between the solar traditions of Kerala and other regions. The Panchangam system was dynamic and was continuously refined through empirical evidence. In the case of Jyesthadeva, his Yuktibhasa contained rationales for series approximations. It facilitated more precise calculation of longitudes. The currently surviving manuscript treasures stored in institutions such as the Oriental Research Institute in Thiruvananthapuram offer critical source materials that shed light upon algorithmic approaches, eclipse records, and socio-cultural integrations related to the computation of the Panchangam.

Kerala School of Astronomy and Mathematics, Temple Astronomy and Agricultural Calendars

The Kerala School of Astronomy and Mathematics was the acme of pre-modern Kerala's intellect. It focussed on temple observatories and directly influenced both time-reckoning and agricultural calendars. It is established by Madhava of Sangamagrama (c. 1340-1425) in Tirur. The institution hosted numerous scholars such as Parameshvara (observed eclipses from 1395-1432), Nilakantha Somayaji (Tantrasangraha, c. 1500) and Jyesthadeva (Yuktibhasa, c. 1530), operating from sites in Thrikkandiyur and Vatasseri. The innovations in calculating series for sine, cosine, pi (Madhava's values reaching up to 3.14159265359) and spherical trigonometry and constructing empirical corrections to planetary models (anticipating calculus centuries ahead of Europeans) are the main contributions from the school. The School also produced manuscripts and passed down through teacher-pupil lineages such as Govinda Bhattathiri to Parameshvara to Nilakantha, focusing on demonstrable proofs over dogma. They employed gnomons and water clocks for observations in temple environments.

The integrated astronomical research undertaken at temple observatories made direct use of these scientific achievements. Many of these was incorporated into temple designs. The buildings often included

arrangements for solar alignment to cast shadows from gnomons (shanku yantras) in order to calculate the solstices, equinoxes, and cardinal directions. Examples abound in shrines such as Padmanabhaswamy Temple, where equinoctical sunsets are aligned through certain openings in the temple walls. Astronomical findings from temple sites are correlated with both the agricultural calendar and timing of various rituals. Many shrines boast features for solar alignment on days corresponding to equinoxes or solstices. It helps to synchronize rituals throughout the community in the local rice-spice economy. For all these computations Parameshvara developed a system known as Drigganita which would provide astronomically accurate ephemerides to guide temple observations and the calculations underlying the calendar.

The influence on agriculture is readily apparent. The success of planting and farming depended on accurately forecasting monsoon conditions (using astronomical factors known as yoga and tithi, which could avert losses by preventing crop damage) and utilizing stellar observations in order to optimally time planting to yield maximum crops within the terrain and climatic conditions of Kerala. Even maritime endeavors depended on this precise knowledge. Navigators on the Indian Ocean relied on similar observations using navigational devices known as kamal and tables to determine latitude. The continuum in scientific activity into the nineteenth century with Sankara Varman's Sadratnamala in 1819 which computes to seventeen decimal places indicates how the lineage of this knowledge persisted until the establishment of the Thiruvananthapuram Observatory in 1837 by the Maharajah Swathi Thirunal. Some incredibly rare manuscripts including records of eclipses and palm leaf proofs indicate the incremental refinement of methods which offer many insights into this holistic scientific worldview.

Parameshvara's Eclipse Records and Observational Astronomy

Vatasseril Parameshvara Nambudiri (c. 1380-1460 CE), a central figure in the Kerala School of Astronomy and Mathematics from Alattur (Alathiyur) on the banks of the Nila (Bharathappuzha) river in Tirur. He stands out as a pioneering proponent of empirical observational astronomy in medieval India. Over a remarkable span of approximately 55 years (roughly 1393-1445 CE or 1398-1431/1432 CE according to various manuscript references), Parameshvara conducted systematic observations of solar and lunar eclipses, planetary conjunctions, and positions. He used his observations to critique and refine the prevailing Parahita system of Haridatta (c. 683 CE) and earlier Siddhantic parameters inherited from Aryabhata and others. His work emphasized direct verification—"the planets have been observed by me for fifty-five years and they differ from the positions derived through Parahita-Ganitam"—as recorded by his disciple Nilakantha Somayaji, highlighting a scientific methodology of iterative comparison between computation and observation that was rare for its time.

K. Chandra Hari's seminal 2003 analysis in the Indian Journal of History of Science (38(1): 43-58) details that Parameshvara recorded eight solar eclipses and five lunar eclipses in his surviving works, with additional references suggesting broader coverage including up to 12 solar and more lunar events in some manuscript traditions. Key documented observations include those in his Siddhantadipika (a commentary on Govindasvamin's Mahabhaskariyabhashya), noting specific events at locations such as Navaksetra (1422 CE), Gokarna (1425 CE and 1430 CE), and near his home in Alattur/Vatasreni. One notable epoch is the solar eclipse of July 15, 1411 CE, which served as a reference point for his eclipse treatise Grahanamandana. These records were made using traditional instruments like the gnomon (shanku), water clocks, and naked-eye sightings and often at temple-linked sites or coastal vantage points suited to Kerala's geography.

Parameshvara's eclipse data fed directly into his Drigganita (composed c. 1431 CE), a revised computational scheme for almanacs (Panchangams), eclipse predictions, and planetary longitudes. It achieved greater accuracy by adjusting parameters for solar and lunar anomalies, node positions, and parallax. He authored dedicated eclipse texts: Grahanamandana (computational karana text with epoch 1411 CE), Grahanastaka, Grahananyayadipika (theoretical rationale), and Grahanavyakhyadipika. Modern validations using planetarium software and VSOP87 planetary theory (as in Chandra Hari's study) show his recorded timings and longitudes had only minor discrepancies-often attributable to manuscript transmission errors rather than observational inaccuracy-demonstrating precision remarkable for pre-telescopic astronomy at Kerala's latitude (~10-11N). The comparisons reveal his solar eclipse longitudes aligned closely with modern retro-calculations underscoring the efficacy of his empirical corrections over purely textual traditions.

These observations profoundly influenced successors. Nilakantha Somayaji explicitly drew on them for Tantrasangraha (c. 1500 CE), incorporating refined eclipse methods and planetary models. His son Damodara continued the lineage. Parameshvara's approach critiqued earlier authorities like Varahamihira while maintaining continuity with Siddhantic frameworks, proposing adjustments to mean motions, apsides, and eclipse limits. Rare manuscript evidence from palm-leaf collections (over 25 works attributed to him, per Pingree's catalog) preserves these records, including verses on discrepancies between predicted and observed events, which guided revisions in temple astronomy and agricultural calendars. His 55-year was attributed as "penance" as poetically described in Malayalam sources like K.V. Sarma's references..In the broader context of pre-modern Kerala, Parameshvara's records exemplified the integration of mathematics, observation, and application. They corrected cumulative errors in long-term predictions, improving Panchangam reliability for rituals, marriages and farming cycles tied to the Kollam Era. This empirical rigor connected to later developments and highlights Kerala's contribution to global astronomy.

Nilakantha Somayaji and Tantrasangraha

Nilakantha Somayaji (circa 1444-1545), alternatively known as Kelallur Nilakantha or the Somayaji of the Garga gotra, was arguably the most multifaceted and significant astronomer and mathematician in the Kerala School tradition. He was born in Trikkandiyur (near Tirur, Malappuram district) on the banks of the Nila river to a Nambudiri Brahmin family. As a student of Damodara, son of Parameshvara, he followed in the empirical and computational footsteps of his predecessors like Madhava of Sangamagrama and Parameshvara. The length of Nilakantha's life (approximately one hundred years) enabled him to consolidate, expand and extend the earlier systems, leading to the production of many independent works. He has simultaneously continued teaching and undertook astronomical observations at temple-associated educational centers. Nilakantha combined the study of ancient Siddhantic texts (such as the Aryabhatiya) with direct observation and demonstrated that all observations were iteratively refined through rational derivations called 'yuktis', which his student Jyesthadeva subsequently explained later.

His seminal work is the Tantrasangraha meaning "A Compilation of the System" was written between 1500-1501 CE. It is a concise Sanskrit text of 432 verses in the anushtubh meter. It is divided into eight chapters (prakaraas). The work is considered of similar importance to the Aryabhatiya and Bhaskara's Siddhantairoma in shaping later Indian astronomy. Far from being a purely theoretical work, the Tantrasangraha is an invaluable and indispensable computational manual dealing with mean and true planetary longitudes, diurnal problems, eclipses, visibility, etc. It introduced important modifications compared to earlier scholars. Editions with commentaries have been published by S. K. Pillai (1958) and

K. V. Sarma (1977) respectively. These comprise Laghu-vivti (a prose commentary) and Yukti-dpik (a verse commentary) by akara Vriyar, with further elucidations in Jyesthadeva's Malayalam commentary called Yuktibh. The work has now also been made accessible by a modern English translation with meticulous mathematical explanations of its complex equations by K. Ramasubramanian and M. S. Sriram (2011, Springer).

Perhaps the most important innovation in Tantrasangraha concerns Nilakantha's revision of the classical Indian models of planets, particularly in the case of the interior planets Mercury and Venus. Based on Parameshvara's earlier observational records, Nilakantha prescribed that the 'manda' (equation of the center) should be applied to the 'ghrocca' which he identified as the mean heliocentric position instead of the mean Sun. The resultant modification provided a unified theory of planetary latitudes for both interior and exterior planets. The 'manda' that was considerably more accurate than the corresponding equations from earlier Indian, Greco-Islamic or even early European works before Kepler. The planetary epicycles are of course added on to a system of eccentric orbits, where the planets move around the mean Sun, and the mean Sun is in turn orbiting the Earth which is a geo-heliocentric (akin to the Tychonic system). This model can also be traced in Nilakantha's other works such as his Siddhntadarpana (31 verses), Golasra (56 verses) and Aryabhayabhya . Aryabhayabhya contains some crucial astronomical data including the mean parameters of planets that can only be extracted through inferring them from his eclipse computations contained in another work. Another treatise called Golasra by Nilakantha explains in 56 verses a concise description of the spherical parts of the sphere and their mutual relations and of the geometry involved in astronomical computations. It also briefly refers to his planetary theory and their movements and eclipse computations and visibility calculations as well as predicting latitudinal motions. These later predictions come very close to Keplerian computations while remaining conceptually within the earlier Ptolemaic-style epicycle-eccentric paradigm.

The Tantrasangraha was a working tool that directly fed into the production of the Kerala Panchangam (almanac), agricultural almanacs (for calculating timely agricultural activities), temple festivals and navigation. It promotes the concept of yuktis, rational derivations, that undergird empirical knowledge and astronomical computation. The 500th anniversary of the Tantrasangraha conference in 2000 (Chennai and Shimla) drew attention to the work and its significance. Kerala's palm leaf manuscripts which were housed in various libraries preserve the variants of the Tantrasangraha, whose textual study allows philologists to understand the process of transmission. Besides the Tantrasangraha, Nilakantha authored other works such as Jyotirmms (dealing with the validity of astronomical observations) and several treatises on eclipses. He effectively bridged medieval Indian astronomy to a high level of precision by providing a rich resource for the study of native calculus and planetary theory .

Influence of astronomical studies on agriculture, navigation and links to modern era

Astronomical studies made during pre-modern times in Kerala have impacted agriculture, navigation, and formed an empirical link between old traditions and later modern institutions. Agriculture is primarily influenced by solar position, Nakshatra system and forecasts for monsoon derived from Panchangam predictions. These systems guide cultivation patterns in Kerala landscape dependent on southwest and northeast monsoons. Sowing is dictated by transits (like before Edavappathi) and harvesting during Kannikkoythu or Makarakkoythu, coordinated at village level through temple calendars. This minimizes damage due to flash floods in paddies and spice gardens, and combines religious observance for prosperity.

For navigation, mariners along Kerala's Malabar coast used stellar observation, planetary tables and latitude charts based on Kerala School computations. They used the panchangam for undertaking trade in pepper, spices and textile within the Indian Ocean. Accurately determined eclipses and conjunctions assisted in longitude estimations apart from monsoon wind calculations. Astrological and astronomical charts from temples served as guidance for voyages. This tradition links up to the modern era with the compilation of Sadratnamala by Sankara Varman. These studies, patronized by the Travancore kingdom, brought traditional and Western elements together and through C. M. Whish's publication on Kerala mathematics. Its findings were published globally. It serves as the scientific heritage of modern Kerala in many institutions and links old astronomical observations of temples to recent research.

Conclusion

The study of astronomy, agricultural calendar and systems of time-reckoning in pre-colonial Kerala shows us that a highly advanced indigenous scientific tradition thrived in the region. Astronomy in pre-colonial Kerala was not a recondite intellectual pursuit. It is an operational corpus that guided everyday agriculture, sea navigation, religious observances and administrative routines. A distinct chronological measure of time (the Kollam Era) characterized the temporal system of Kerala and traditions of Panchangam translated elaborate astronomical calculations into a form intelligible to ordinary men. The discoveries of the Kerala School of Astronomy and Mathematics show the level of advancement achieved in scientific thinking in this region. Madhava of Sangamagrama, Parameshvara, Nilakantha Somayaji and Jyesthadeva used mathematics for astronomical studies in ways which complemented each other and produced remarkable results in both fields. The precise measurements of eclipses undertaken by Parameshvara and the theoretical calculations made by Nilakantha Somayaji are examples of a scientific tradition that possessed careful observation, empirical verification and refinement of knowledge. These achievements contributed to the intellectual history of India and provided pragmatic models for calculation. The tradition of astronomy in pre-colonial Kerala played a crucial role in environmental adaptation and social organization as an operational tool. This interconnectedness of celestial knowledge with agrarian cycles, temple traditions and maritime networks led to a scientific milieu which shaped the entire scientific history of Kerala. The tradition did not disappear entirely after colonialism and indeed laid the foundations for later astronomical research institutions in Kerala which continue to uphold its tradition of scientific excellence.

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