Epistemology and Language in Indian Astronomy and Mathematics

Roddam Narasimha

Abstract This paper is in two parts. The first presents an analysis of the epistemology underlying the practice of classical Indian mathematical astronomy, as presented in three works of Nilakantha Somayaji (1444–1545 CE). It is argued that the underlying concepts put great value on careful observation and skill in development of algorithms and use of computation. This is reflected in the technical terminology used to describe scientific method. The keywords in this enterprise include parīkṣā, anumāna, gaṇita, yuktī, nyāya, siddhānta, tarka and anveṣaṇa. The concepts that underlie these terms are analysed and compared with such ideas as theory, model, computation, positivism, empiricism etc. In a short second part, it is proposed that the primacy awarded to number and computation in classical Indian science led to an artificial language that did include equations but emphasized displays that facilitated calculation, as in the Bakshali manuscript (800 CE?). It is further argued that echoes of these concepts can be recognized in current science, where computation is once again playing a greater role triggered by spectacular developments in computer technology.

Introduction

It is now widely accepted that many scientific ideas flowed from one civilization to another across the Eurasian landmass over the millennia. Classical Indian astronomy took the idea of epicycles from the Greeks; pre-modern

R. Narasimha
Jawaharlal Nehru Centre for Advanced Scientific Research/National Institute of Advanced Studies, Bangalore, India
e-mail: roddam@caos.iisc.ernet.in

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Europe took the idea of the present system of numerals from India (through the Arabs); ideas on trigonometry have moved back and forth; India was in close contact with Babylonia since around 2000 BCE and acquired the sexagesimal system, still in use for measuring angles and some other quantities all over the world. However, it is fascinating to consider the inverse question of what the different cultures did not borrow (perhaps even refused to borrow) from each other, in spite of close contacts over centuries. For example, the Indians who borrowed epicycles did not take to either the assumptions that underlie Ptolemy’s astronomy or the axiomatic method used by Euclid. Each culture appears to borrow selectively. Tools that support or promote the agenda of the culture are more easily adopted than the philosophy (or epistemology) underlying the invention of the tools.

Differences in approach to the same subject or to organizing the same observational data (as in astronomy) are not uncommon. For example, Ptolemy’s celebrated text *Almagest* (~150 CE) devotes the first of its 13 books entirely to the question of the assumptions it makes, on the basis of which the results in the rest of the text are deduced by Euclidist methods. Āryabhaṭa (5th c. CE) adopts a wholly different approach to the subject, although he uses Greek epicycles. Instead of starting with assumptions and models, he begins with lists of numerical parameters that he needs in the 60 or so algorithms described in the book. Euclid starts his book on geometry with axioms, the Śulba-sūtras start with units of length measurement.

Such facts lead one to conclude that the approach to acquiring rational, objective knowledge can be different in different cultures. Neugebauer (1975) remarks on such differences between the Greeks and the Babylonians, for example: Babylonian methods were ‘arithmetical’, Greek methods start with models and the kinematics of planetary motion. A fundamental difference between the approaches of the two cultures has resonance even in modern science. Richard Feynman, perhaps the greatest theoretical physicist of the second half of the 20th century, said (Mehra 1994)

“There are two ways of doing physics: the Greek (from first principles, axioms) and the Babylonian (relating one thing to another). I am a Babylonian ... I have no preconception about what nature is like or ought to be.

The key epistemological issue is about those preconceptions. When such preconceptions, alternatively axioms, are successful in comparisons with observation, we may have outstanding new science. When no check with reality is possible, the axiomatist approach can lead us astray. Current controversies on string theory (‘it is not even wrong’, it has been said) provide a striking modern example. It is necessary to realize that such differences are fundamentally epistemological, i.e. reflect different views on what constitutes valid, reliable or acceptance-worthy knowledge.

Now epistemology in general—i.e. beyond science—has been a major preoccupation in Indian philosophical systems. It is therefore interesting to explore in what way the practice of mathematical astronomy in India was