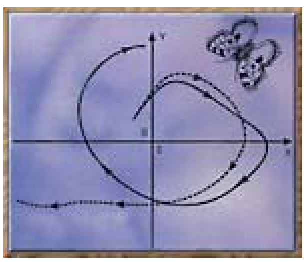
Deterministic Chaos

This year's National Science Day Lecture was delivered by Prof N Kumar, Director, Raman Research Institute, at the Systems Auditorium on 4 March 1999. The lecture, on *Deterministic chaos*, proved to be quite a splendid narrative.

Prof Kumar's lecture, which was approximately based on the introductory chapter of his very readable 1996 book *Deterministic Chaos: Complex Chance out of Simple Necessity* (I thought the lecture had even more flair and magic than the book) opened by recalling that the laws of classical physics are deterministic; and noting that these laws have served us rather well (e.g. the astonishing accuracy with which eclipses can be predicted). In fact so widespread is the acceptance of these laws that most of us sincerely believe that the universe is 'calculable', and therefore 'fully predictable'. (But then don't we still talk of 'chance' and 'randomness'? We do, indeed, explained Prof Kumar, but arguably as an alibi for ignorance!). The big shock came when it was established that the behaviour of completely deterministic systems may be impossible to predict because of the underlying complexity; the best that can be achieved is a horizon of limited predictability.

Why does this happen? That's because of the phenomenon of sensitive dependence on initial conditions (sic-ness) first noticed by Poincaré in 1903. Prof Kumar explained the concept wonderfully: he talked of the critically poised needle, of how the 'ever-so-slight-a swerve' can send a billiard ball to an entirely different end destination, how the flapping of a butterfly's wings in Brazil can set off a tornado in Texas. The key point, he explained, was that approximately known initial conditions may not permit quantitative predictions which are approximate roughly in the same numerical proportion.



The lecture covered wide ground: the Lorenz toy model in numerical weather prediction, the baker's transformation (which involves all the essential elements of complexity: nonlinearity, stretching, folding back, eternal self-avoidance, contraction etc.), the logistic problem, the dripping faucet and the period doubling route to chaos (first it is 'drip, drip, drip'; then 'pitter, patter, pitter, patter' and eventually a strange kind of music), aperiodic systems and strange attractors (can there be an infinitely inventive drummer? or would it be possible for each of the few hundred early morning walkers at RRI to walk in a fashion so that they don't repeat paths or collide?). The audience particularly enjoyed the sequence of images in which Poincaré mysteriously reappears at iteration no. 240 .. looking almost the same, albeit a little shell-shocked.

Prof Kumar also talked of the 'benefits' of chaos: more energy-efficient mixing of fluids, dispersal of pollutants, encryption for secure public communication, the happy consequences of the 'implicate universe' (fewer variables to study), studying stock markets, epidemics and ECG's and said that chaos is not really an undesirable thing. He also discussed why chaos theory has not been particularly successful in studying turbulence (chaos can't tackle spatio-temporal problems too well).

It was therefore a great pleasure to sit through Prof Kumar's superbly articulated lecture. In the late 1980's, when chaos was high fashion, for some of us the hype reached such a crescendo that we involuntarily 'shut off' from the subject. Prof Kumar's remarkable narrative a decade later allowed one to renew one's acquaintance with the subject, and realise that, hype notwithstanding, the concept of deterministic chaos has indeed significantly influenced the way we model and understand complex real world phenomena.

Srinivas Bhogle