A numerical astrophysical observatory

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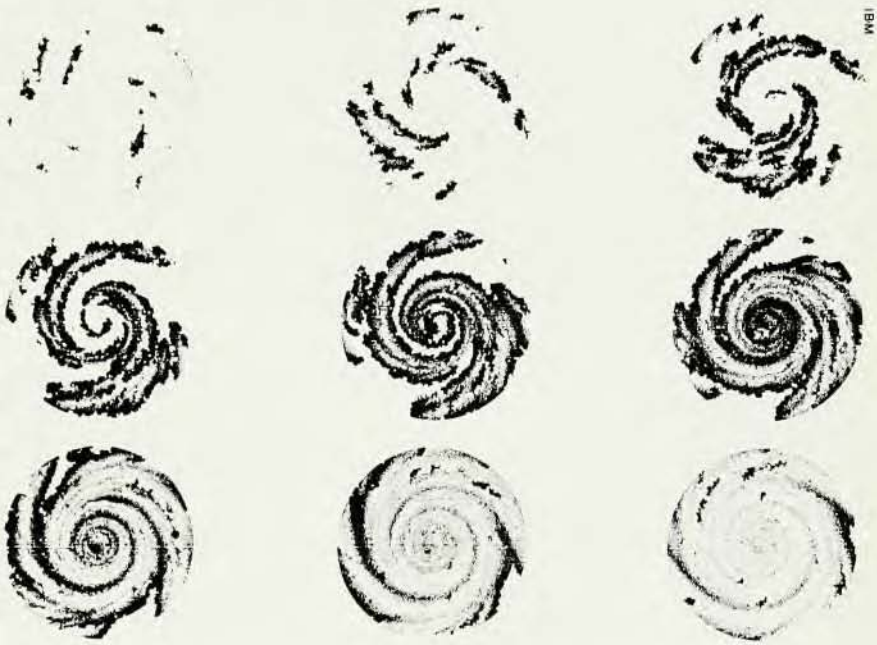

Kenneth Wilson's editorial in May (page 128) seemed even more pertinent when we visited Cray Research during the 162nd meeting of the American Astronomical Society in St. Paul. I wish to emphasize the dismal state of computing facilities in astrophysics, and to propose a format for a remedy.

As astrophysical observations increase in spatial, temporal and frequency resolution, theorists by and large abandon efforts at interpretation or shift their ground to ill-observed details. Objects like the Sun, the Orion and Crab nebulae, the hydrogen clouds in M17, the Andromeda and Magellanic galaxies and even extragalactic radio jets like NGC 6251 are simply too close for comfort: They are known in an amount of detail that is too much to handle—not, alas, because the relevant physics is too much, but because the relevant computations are too heavy. Indeed, previous analytic estimates and educated guesses about the behavior of these objects have surrounded the physical terrain pretty well (for example, magnetohydrodynamics, plasma physics, radiative transfer, general relativity). But, to take just one example, it is an affront that the MHD equations, four decades after their conception, have not yet been seriously applied to large-scale astrophysical problems of more than elementary complexity, because full three-dimensional detail is required in realistic cases.

It is true that analytic estimates have often been quite artistic, and it is likewise a fact that no large-scale number crunching should be undertaken without considerable analytic groundwork. Yet it is not true, as some have been heard to claim, that there is no such thing as computational astrophysics. Indeed, significant large-scale work has been done already, for example, on jets in galactic nuclei, on star formation regions and on the origin of galaxies. Unfortunately, the symmetries imposed by lack of available time are artificial; moreover, these results were obtained on machines with severely limited access (for example, at Los Alamos or Lawrence Livermore, which are available only to a happy few).

The solution to these problems can be illustrated by analogy with an astronomical observatory. There ought to be the computational equivalent of, say, Kitt Peak National Observatory (or the Very Large Array radio telescope), with a fourth- or fifth-generation computer plus supporting staff. If advances in science are really made, as is often claimed, by a dialog of experiment and theory, it is perfectly reasonable to equip both these branches commensurately. A numerical observatory could be run in the same format as Kitt Peak or the National Radio Astronomy Observatory, with the aim to "observe" in parameter space. This analogy easily brings some of the present ills into perspective:

- restricted machines, such as the LASL and LLL computers: imagine that the Kitt Peak 4-m telescope, or the VLA, were classified
- the trend toward "everyone their own VAX," popular among university administrators, is as silly as saying to observers "everyone their own binoculars"
- the "next-generation telescope," so favored by the observational community, is a piece of virtually unproven technology, whereas even supercomputers can be bought off the shelf (corollary: the budget for a numerical observatory is easily and accurately predictable)
- the cost *overruns* on the Space Telescope would buy about 30 (thirty) full-fledged Cray systems.

In conclusion: A "numerical observatory" for astrophysics is needed, possible and comparatively cheap. It would allow a proper attack on, among other things, cosmic magnetohydrodynamics; plasma physics; nonspherical stellar structure; binary-star evolution; galaxy, star and planet formation; and cosmology. It would bring computing power to researchers without access to classified machines. And a numerical observatory need not be visited for the work to be done. Research could remain centered at the universities, big and small, where it belongs, as long as telephone lines exist. □

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