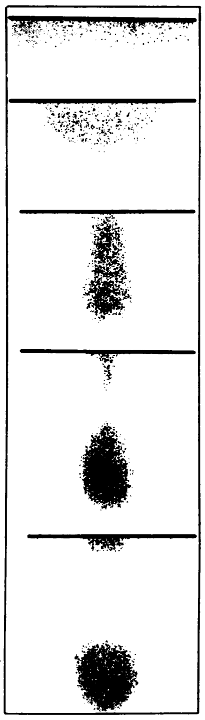
Computing the way a liquid drips



Greenspan/Univ. of Texas

A slowly dripping faucet serves as an elegant demonstration of the subtle interplay between gravitational and electrical forces. Water hanging from a surface gathers into a dangling bulge that gradually lengthens. The bulge develops a neck, which becomes narrower and narrower until the drop breaks away. The same process of drop formation can now be observed step by step on a computer screen in a novel computer simulation taking into account how liquid particles behave.

To obtain his pictures of hanging and falling drops, mathematician Donald Greenspan of the University of Texas at Arlington takes what he calls "a distinctly different approach." Instead of modeling drops as blobs of liquid held together by surface tension, he concentrates on the effects of gravity and on the attractive and repulsive electrical forces between molecules of the liquid.

"We're interested in the dynamics of what happens," Greenspan says. Information about such mechanisms could lead to a better understanding and improved control of drop formation, whether in chemical sprays or raindrops.

In general, two atoms or molecules interact only when they're close together. If pushed together, they repel; if pulled apart, they attract. At close quarters, the repulsive influence far outweighs the attractive effect, and individual molecules move erratically, colliding and rebounding quite violently.

To subdue these motions and make them mathematically more tractable, Greenspan clumps the large number of liquid molecules actually present in a typical drop into a relatively small number of larger units called quasimolecules, or particles. That allows him to express the interactions between neighboring particles more simply. "When you do that you have qualitatively the same result as for a molecule, but you have more stability overall and less local volatility," he says.

When such modified molecular forces are incorporated along with gravity into the appropriate equations of motion, Greenspan can compute how a collection of these particles would behave. In his hanging drop model, he follows the motion of 2,703 particles. Of these, 203, which represent the horizontal solid surface, are closely packed and stationary. The remaining 2,500 particles, representing the liquid, move about freely, interacting whenever they are less than a certain distance apart. Computing a typical sequence takes up to three hours on a Cray X-MP supercomputer. The result is a qualitative picture of drop formation.

"I think the pictures we get are beautiful," says Greenspan. The falling drops even oscillate, just as real drops do (SN: 3/2/85, p.136).

Greenspan's model also includes adhesion between the solid surface and the fluid molecules. By setting the parameters in his equations appropriately, he can show under what conditions a dangling drop fails to fall.

Greenspan's drop-formation model is strictly qualitative and doesn't apply to any particular liquid. To make the model more quantitative would require the collection of experimental data to fix the values of the various parameters in Greenspan's equations. Because such measurements are generally not yet available, Greenspan presently selects values that make the pictures look realistic. As improved experimental measurements become available and the model becomes more quantitative, Greenspan's technique shows promise as a way of studying the details of how drops form — how factors such as temperature and chemical composition affect properties such as drop size and rate of formation.

Greenspan is using his quasimolecule technique not just for studying hanging drops but also for investigating a wide variety of physical systems. He and his students have developed such models for vibrating strings, cracks and fractures in solids, vortex formation and turbulence in fluids, convection currents in the atmosphere and the propagation of stress waves in metal bars.

In each case, the computer's calculations reflect the physical situation at each step during the simulation. No particles are created or destroyed. Quantities such as energy and momentum are conserved at all times.

The quasimolecular approach contrasts sharply with other computer simulation techniques, in which the steps in a computation are a means to an end and don't necessarily mirror the physical situation. Starting with molecular behavior, these more conventional statistical techniques allow the derivation of relationships between quantities such as pressure, energy and volume but don't indicate what happens at the molecular level to create the physical situation.

The quasimolecular approach is a way to do physics directly on the computer, Greenspan says. His paper on modeling drop formation will appear later this year in the INTERNATIONAL JOURNAL OF MATHEMATICAL AND COMPUTER MODELLING.

— I. Peterson

Commercial space launchings scheduled

The first schedule of planned satellite flights that private space launching companies will orbit, released last week, is being hailed in some quarters as a new phase in the U.S. space program. "Suddenly," says policy analyst Larry Martinez with the Department of Transportation (DOT), "it's 1973 — the year before two guys in a garage in Sunnyvale, Calif., came up with the Apple computer."

Apple has not taken up launching satellites. Martinez refers rather to what he sees as a potential techno-business revolution, as significant in a way as the one that followed the introduction of the personal computer. Historically, NASA has handled all commercial space launches in the United States. But in a major policy change, DOT is now responsible for licensing all launches of satellites whose owners — whether federal agencies, private firms or foreign governments — hire commercial companies to orbit their craft with expendable rockets fired from U.S. sites.

The newly announced commercial launch schedule, or manifest, reflects President Reagan's January national space policy statement, which calls both for eliminating government launch competition with the private sector and for avoiding unnecessary use of the space shuttle's human crews for launchings.

The first version of the manifest, which so far extends through May of 1992, represents 18 licenses for satellite launchings and two for sounding rockets. Topping the list is India's INSAT 1-D communications-and-meteorology satellite, to be orbited next March by McDonnell Douglas atop one of its Delta rockets.

The manifest lists nine U.S. launchings, among which are the German ROSAT X-ray telescope and NASA's Extreme Ultraviolet Explorer satellite (both formerly planned as launches by the shuttle), as well as the Combined Release and Radiation Effects Satellite for NASA and the Defense Department. Also included are three GOES weather-watchers for the National Oceanic and Atmospheric Administration, a Navy communications satellite and the two sounding rockets, to carry microgravity experiments. The other entries, though also being launched by U.S. companies, are all communications satellites for foreign or international customers — Britain, Indonesia, Japan, India and consortia such as INTELSAT.

— J. Eberhart