Making 'common sense' of Beltrami vortex geometry

As late as December 1990, Dr. Bostick continued his contributions to a project seeking to construct a universal mathematical physics. Charles B. Stevens reports on this ongoing project.

We present here Part 3 of Dr. Winston Bostick's "The pinch effect revisited," which first appeared in the inaugural issue of *International Journal of Fusion Energy* in March 1977. Dr. Bostick was among the first scientists to work on the controlled thermonuclear fusion research (CTR) program in the United States. Following early experiments in plasma pinches for CTR, Dr. Bostick pioneered the applications of this laboratory work to better understanding astrophysical processes, such as galaxy and star formation. In fact, he carried out experiments to show how electromagnetic plasma processes could account for the geometry and dynamics of spiral galaxies, where the traditional approach, which is limited to considering the effects of gravity, could not.

In December 1990—shortly before he lost his fight with cancer on Jan. 19—Dr. Bostick's work figured prominently at a seminar held at the 21st Century Associates offices to review the latest data from the Hubble Space Telescope, which consisted of wide field images of the Nebula Orion. These images gave the first detailed look at a plasma "jet" (most probably a Beltrami plasma vortex) which is directly connected to a star that has just formed. In reviewing the specifics of why this data indicated once again that electromagnetic plasma processes provided a far more fruitful path than the traditional gravity approach to understanding how a star forms, various geometric constructions for some possible connections between Beltrami plasma vortex configurations and negative curvature minimal surfaces were presented. The reader may find these helpful as an introduction to the geometry of Beltrami vortices.

The spiral helical geometry of a plasma pinch column, that is, a plasma through which an electric current is passing, is shown in **Figure 1.** This geometry of flow is taken as "force free," since all of the fields of force are parallel to these helices; that is, the fluid velocity field, the electric field, the magnetic field and the vorticity are all directed—"flow"—along paths which follow these helices. If such fields of force are parallel, or rather, more generally, colinear, then their interaction is zero and the configuration is termed "force free."

This Beltrami vortex geometry bears a great resemblance to the helicoid, as shown in **Figure 2,** where the vortex column is taken as having an infinite radius. The helicoid surface intersections with cylindrical surfaces of varying radius define a family of helices which are like the family of helical flow lines in the Beltrami vortex. The "right" helicoid shown here is generated by a line which rotates around and moves along the axis of the helicoid.

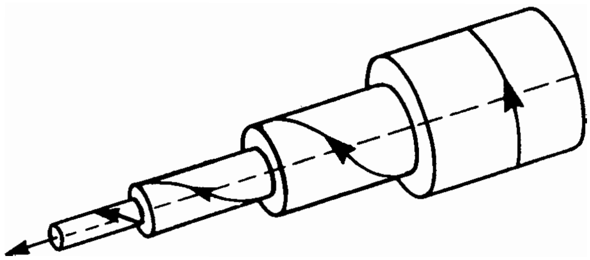
There is an actual physical connection between any helix and the helicoid. The direction of the velocity at any point along a given helix flow line can be determined by constructing a tangent to the helix at that point. The centripetal acceleration of this velocity will be directed along a line perpendicular to the tangent line and passing through the axis of the cylinder on which the helix is found. Thus, this centripetal acceleration is directed along the line which generates the helicoid surface.

Minimal surfaces and the helicoid

As is developed by David Hilbert in his more popular work *Geometry and the Imagination,* and in a number of other books like C.V. Boys's *Soap Bubbles,* the helicoid is a minimal surface having the same negative curvature as the most characteristic minimal surface, the catenoid. The catenoid is shown in **Figure 3a.** In other words, it is possible

FIGURE 1

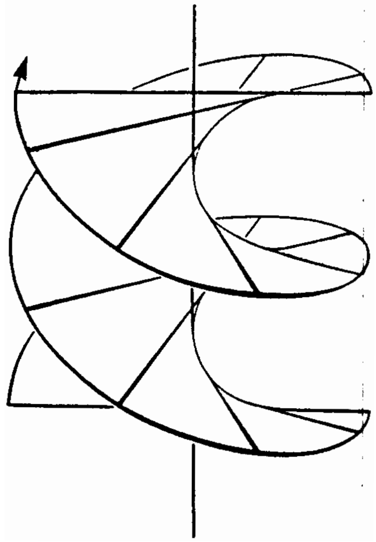
General features of the Beltrami vortex configuration



The chief characteristics of the Beltrami vortex configuration are the helical flow lines on each cylindrical surface of a plasma pinch column. Helices of the same pitch cover the surface of each such cylindrical surface. The helical pitch decreases as the radius at which the cylindrical surface is taken. Along the axis of the column the pitch is infinite—i.e., the helix is a straight line. Along the surface of the plasma column—the cylindrical surface of greatest radius—the pitch becomes zero and the flow lines are circles.

FIGURE 2

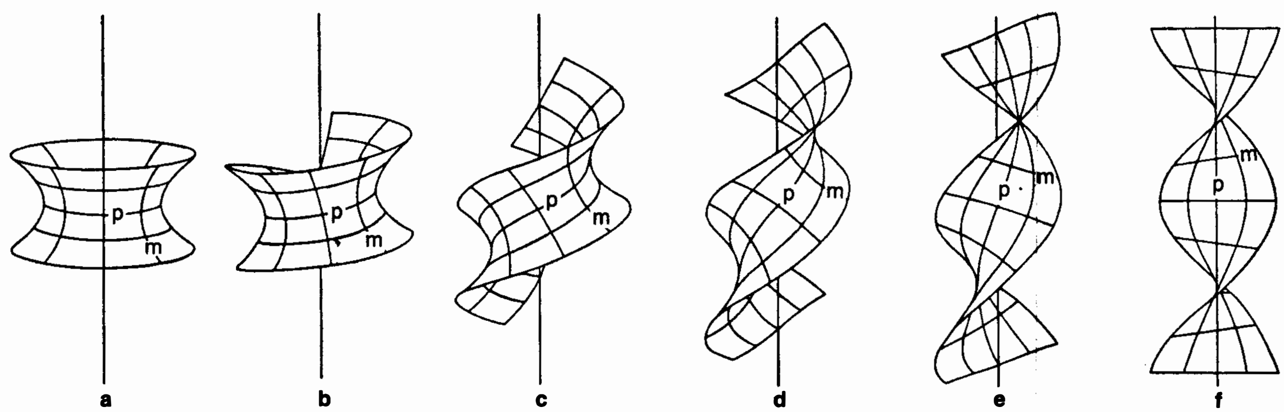
How a helicoid is generated



The helicoid is like a spiral staircase and generated by a rotating line that also moves along its axis of rotation. It determines helices of decreasing slope as one moves away from the central axis of the "staircase," and circles are generated. At a zero radius, the intersection becomes a helix of infinite slope, i.e., it becomes the axis of the cylinder.

FIGURE 3

How a catenoid is transformed into a helicoid



The catenoid is the most characteristic form of the minimal surface of negative curvature. A cross section made with a plane perpendicular to its axis generates a circle. A cross section which contains the axis produces a catenary curve—the so-called hanging chain. If we generate a soap bubble between two parallel rings, the resulting surface of the soap bubble will be the catenoid.

In step a *the catenoid surface is cut along one of its catenary cross sections. Then in steps* b, c, d, e *and* f *the smallest circle cross section, marked with a p, is unbent into a straight line. As a result the two largest cross-section circles of the catenoid surface are bent into the two helices of the helicoid. Note also that the catenary cross-sections unbend into straight lines—the same lines that are traced out by the generating line of the helicoid.*

to "bend," without stretching or tearing, the helicoid into the catenoid. This process of bending a helicoid into a catenoid, or vice versa, is essentially the same as bending a flat sheet of paper to form a cylinder. The difference is that the helicoid is both bent and twisted to become the catenoid.

The transformation by bending of the catenoid into a helicoid is shown in the rest of Figure 3. This transformation demonstrates one essential quality of Gaussian surface curvature: The surface curvature is intrinsic to the surface and remains the same no matter how we bend the surface.

Negative curvature space

Lyndon H. LaRouche, Jr. suggests in his 1989 book *In Defense of Common Sense* that the Beltrami negative curvature approach to the physical geometry of space-time provides an important advance beyond that made by Eugenio Beltrami's close collaborator Bernhard Riemann. The above geometrical constructions showing the connection between spiral cylindrical action, as characterized by Beltrami plasma vortices and minimal surfaces, while admittedly much simplified, do appear to provide a useful introduction to the broader aspects of the Beltrami approach. LaRouche suggests that Beltrami negative curvature will be crucial for developing insights into the way the nucleus and subatomic particles are created and work.

LaRouche's *In Defense of Common Sense* discusses the connection between his concept of negentropy and Beltrami negative curvature:

"Earlier, we considered one implication of [Cardinal Nicolaus of] Cusa's Maximum Minimum Principle: *the minimal action required to generate the relatively maximum work (e.g. "volume") accomplished.* Now, consider the complementary notion: *The minimum work required to generate the relatively maximum action.* Let us associate the first with the obvious choice of term, *positive curvature.* Let us associate positive curvature with the term *weak forces,* and negative curvature with *strong forces.* Let us examine this array, first, in light of the Riemann Surface Function, and then, the prospect for constructing the more adequate *Riemann-Beltrami* Surface Function. . . .

"Yet, those various measures of *negentropy* define processes which are *bounded by* negentropy, without representing the negentropy itself. Once we shift our focus to the causal sequence of alternating *weak* and *strong* 'forces,' the intelligibility of negentropy becomes a distinct geometrical idea; the negentropic process is then represented intelligibly as *a self-bounded process.*"

As the work of Professors Dan Wells and Winston Bostick has shown, this Beltrami approach is most fruitful for constructing a universal mathematical physics which provides a coherent overview ranging over particle, atomic, plasma and astro-physics, and over the geometries of what is otherwise described today as the weak and strong forces of matter.

The pinch effect revisited, part 3

by Winston H. Bostick

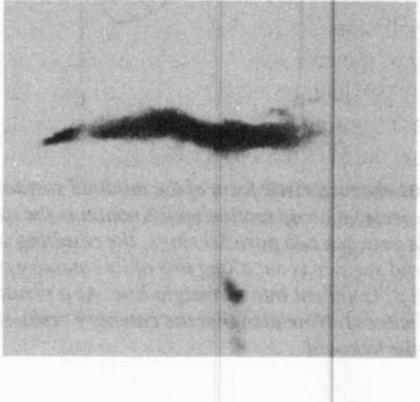
In Part 2 of Dr. Winston Bostick's work, which first appeared in the March 1977 inaugural issue of the International Journal of Fusion Energy, *he discussed the discovery of plasma vortex filaments by researchers in controlled thermonuclear fusion research (CTR). Bostick showed how what appeared to be an anomaly or instability in the existence of these vortex filaments, was actually quite lawful.*

In the beginning of his history of this aspect of fusion research, Bostick described the pinch effect as "the self-constriction of a column of deformable conductor which is carrying an electric current. The constricting effect on the column is produced by the magnetic field pressure resulting from this current, or equivalently, by the Lorentz force produced by the current flowing in its own magnetic field. Thus, in a CTR magnetic-containment device of the pinch-effect type, the containing magnetic field is generated chiefly by the currents flowing in the plasma itself."

An X-ray pinhole photo (**Figure 16**)* with a 50 micron Be screen (>2 kev) shows multiple intense spots imbedded in a

FIGURE 16

X-ray pinhole (75 μm diameter) photo taken at 45°



Be absorber 50 μm (ε≥2 kev). The printing of the photo is light enough to show an intense localized source which is embedded in the broad source of softer X-rays on the electrode axis.