The StarLight Space Interferometer

NASA's Jet Propulsion Laboratory, Pasadena, California

Two papers describe the StarLight space interferometer — a Michelson interferometer that would be implemented by two spacecraft flying in formation. The StarLight formation flying interferometer project has been testing and demonstrating engineering concepts for a new generation of space interferometers that would be employed in a search for extrasolar planets and in astrophysical investigations. As described in the papers, the original StarLight concept called for three spacecraft, and the main innovation embodied is a modification that makes it possible to reduce complexity by eliminating the third spacecraft. The main features of the modification are (1) introduction of an optical delay line on one spacecraft and (2) controlling the flying formation such that the two spacecraft are located at two points along a specified parabola so as to define the required baseline of specified length (which could be varied up to 125 m) perpendicular to the axis of the parabola. One of the papers presents a detailed description of the optical layout and discusses computational modeling of the performance; the other paper presents an overview of the requirements for operation and design, the overall architecture, and subsystems.

This work was done by William Folkner, Michael Shao, and Peter Gorham of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1)*
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Champagne Heat Pump

Relatively safe and environmentally benign working fluids can be used.

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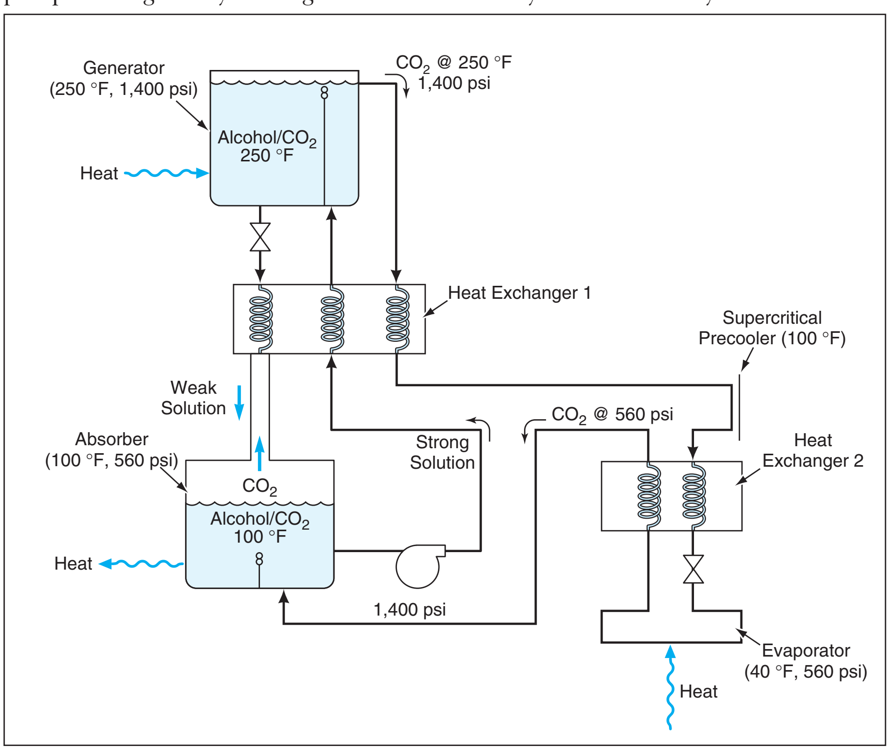
The term "champagne heat pump" denotes a developmental heat pump that exploits a cycle of absorption and desorption of carbon dioxide in an alcohol or other organic liquid. Whereas most heat pumps in common use in the United States are energized by mechanical compression, the champagne heat pump is energized by heating.

The concept of heat pumps based on other absorption cycles energized by heat has been understood for years, but some of these heat pumps are outlawed in many areas because of the potential hazards posed by leakage of working fluids. For example, in the case of the water/ammonia cycle, there are potential hazards of toxicity and flammability.



Carbon Dioxide Is Absorbed and Desorbed in a thermodynamic cycle similar to that of a water/ammonia heat pump. The champagne heat pump is so named because the desorption part of its operating cycle is reminiscent of carbon dioxide effervescing out of alcohol-containing champagne.

The organic-liquid/carbon dioxide absorption/desorption cycle of the champagne heat pump is similar to the water/ammonia cycle, but carbon dioxide is nontoxic and environmentally benign, and one can choose an alcohol or other organic liquid that is also relatively nontoxic and environmentally benign. Two candidate nonalcohol organic liquids are isobutyl acetate and amyl acetate. Although alcohols and many other organic liquids are flammable, they present little or no flammability hazard in the champagne heat pump because only the nonflammable carbon dioxide component of the refrigerant mixture is circulated to the evaporator and condenser heat exchangers, which are the only components of the heat pump in direct contact with air in habitable spaces.

The champagne heat pump (see figure) includes a generator — essentially a heated pressure vessel — wherein a solution of carbon dioxide in the absorbent liquid is heated to generate pressurized carbon dioxide. In a typical application, the solution is heated to a temperature of 250 °F (121 °C), causing the carbon dioxide to be desorbed at a pressure of about 1.4 kpsi (9.7 MPa). The carbon dioxide is precooled, typically to about 100 °F (38 °C) while at this high pressure, then expanded to a pressure of about 560 psi (3.9 MPa); this expansion provides cooling to about 40 °F (4 °C). The carbon dioxide then passes back through a heat exchanger to an absorber, which is another pressure vessel wherein the carbon dioxide goes back into solution, releasing heat. A pump circulates the solution between the generator and absorber.

Carbon dioxide can be an excellent refrigerant fluid for automobiles because its critical temperature is only about 88 °F (31 °C). Therefore, precooling prior to expansion can take place over a relatively wide supercritical temperature range; in contrast, the common refrigerant 134a must be condensed at one specific temperature for a given pressure.

A research group in Norway has produced mechanically actuated carbon dioxide vapor-compression air conditioners for automobiles and has shown those air conditioners to be more efficient and potentially lighter than are comparable air conditioners based on a chlorofluorocarbon refrigerant fluid. The champagne heat pump goes beyond the Norwegian research by replacing mechanical actuation with heat actuation. Potential applications (other than automotive air conditioning) for the champagne heat pump include home and industrial heating and cooling.

This work was done by Jack A. Jones of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1)*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Management Office–JPL; (818) 354-7770. Refer to NPO-19855.

Controllable Sonar Lenses and Prisms Based on ERFs

Compact devices without moving parts would focus and steer acoustic beams.

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Sonar-beam-steering devices of the proposed type would contain no moving parts and would be considerably smaller and less power-hungry, relative to conventional multiple-beam sonar arrays. The proposed devices are under consideration for installation on future small autonomous underwater vehicles because the sizes and power demands of conventional multiple-beam arrays are excessive, and motors used in single-beam mechanically scanned systems are also not reliable.

The proposed devices would include a variety of electrically controllable acoustic prisms, lenses, and prism/lens combinations – both simple and compound. These devices would contain electrorheological fluids (ERFs) between electrodes. An ERF typically consists of dielectric particles floating in a dielectric fluid. When an electric field is applied to the fluid, the particles become grouped into fibrils aligned in rows, with a consequent increase in the viscosity of the fluid and a corresponding increase in the speed of sound in the fluid. The change in the speed of sound increases with an increase in the applied electric field. By thus varying the speed of sound, one varies the acoustic index of refraction, analogously to varying the index of refraction of an optical lens or prism. In the proposed acoustic devices, this effect would be exploited to control the angles of refraction of acoustic beams, thereby steering the beams and, in the case of lenses, controlling focal lengths.

Figure 1 schematically illustrates a sonar assembly according to the proposal. A planar array of acoustic transmitting/receiving transducers would both send out acoustic signals to irradiate targets and, in the acoustic analog of a retina, sense the spatial pattern of return acoustic signals. The transmitted and return signals would be collimated and focused, respectively, by use of two acoustic lenses. The front acoustic lens would be designed to contain an ERF in multiple compartments separated by electrodes, rather than one compartment between a single pair of outer electrodes, in

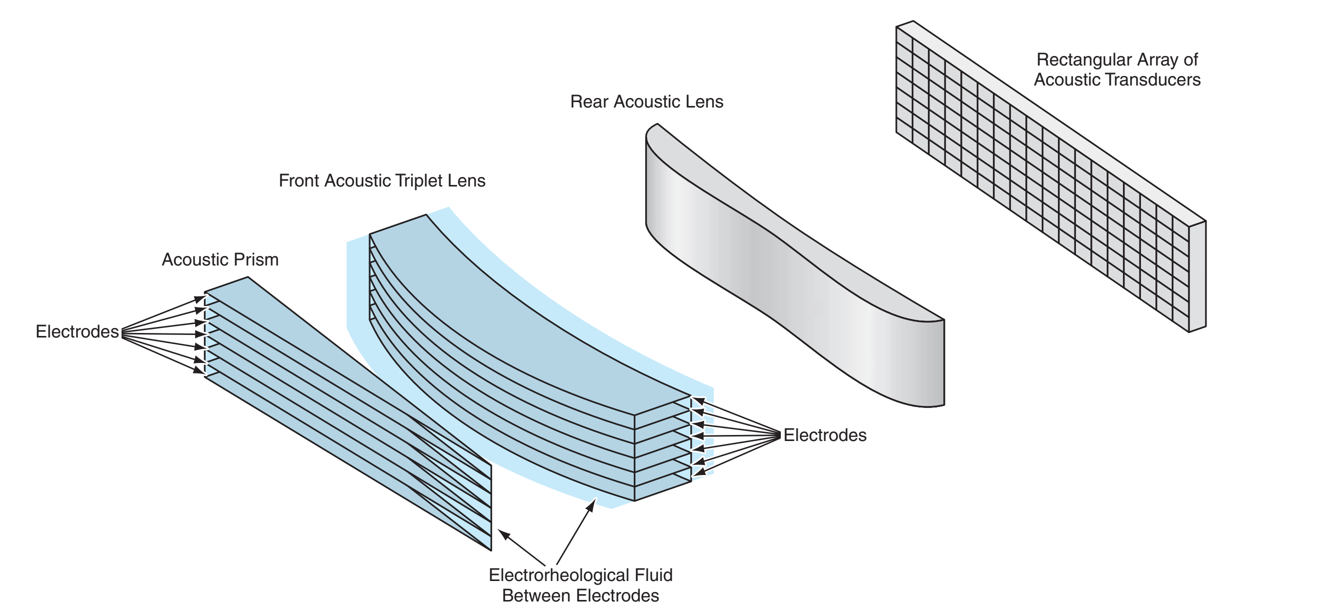

Figure 1. **Electric Fields Would Be Applied** to electrorheological fluids between electrodes to vary the indices of refraction of the acoustic prism and lens, thereby varying the beam direction and focal length, respectively.