## AT: Solar Sails

### You cant win a timeframe to warming- solar sails would take a tremendous amount of time to create and put into use. If its true that extinction would happen in the short term you cant solve.

### Solar sails fail—too fragile to survive in space

Grierson 4. (May 2004. Bruce, social science writer. “My Rocket is Going to Get You to Leo!” Popular Science. www.popsci.com/military-aviation-space/article/2004-05/my-rocket-going-get-you-leo)

The canonization, though, may be premature. Ever since Russian rocket scientkst Fridrikh Tsander ﬁrst wrote about solar sailing in the 1920s, nobody, including NASA, has been able to demonstrate that it works. So sensitive will Cosmos 1 be, up there in the near vacuum, that atmospheric turbulence from solar ﬂares, even outgassing from its own materials—the craft’s own breath, so to speak-—could buffet it in unpredictable ways And there's no guarantee that the fundamental principle is sound. “Theoretically, sail pressure should be 1o times greater than drag,” Delory say; But there’s at least one scientist—Thomas Gold, a noted Cornell University astrophysicist—who thinks it’s hooey. Gold believes the solar-sailing concept violates the thermodynamic law of entropy- one of the prime laws of physics. In his opinion, photons wouldn't move a craft forward. But Louis Friedman, executive director of the Planetary Society, argues that sunlight pressure was proven by Iarnes Clerk Maxwell in the 1860s and has been measured and accounted for on many space missions. Hence, the upcoming test of Cosmos 1. This craft isn't going far and has no particular destination in mind. It's an experiment designed to show that sunlight hitting Cosmos 1 will exert a force strong enough to change its orbit. “People have this image of Cosmos 1 cruis- ing out into the open ocean. when actually it's more like set- ting out in a rubber dinghy in stormy seas,” Delory says. “You'll reach shore iust a little faster than you would by drifting. It's like when Columbus set off—except we're not gel- ting out of the harbor.” Delroy is probably best known for leading the design team that built the Mars microphone—a cigarette-pack- size sensing device that rode the Mars Polar Lander into oblivion five years ago. The device would have transmitted back to Earth the ﬁrst-ever sounds of Mars—pro viding another sensory dimension to our ‘experience’ of the Red Planet—had the lander not been lost. (It fell inexplicably silent moments before touching down near the Martian south pole in December 1999.] In the tripartite division of space enthusiasts. Delory is a Saganite, a person infused with the space-exploration ethos of Carl Sagan. the astronomer who popularized space through his books, TV show Cosmos and film Contact. The adventure. Sagan believed, is not about ﬂags and footprints; it's an existential quest, an attempt to answer the big ques- tions. The Saganites' currency is wonder: They believe in exploring for exploration's sake, and they don't condone exploiting the universe for human gain. ‘There's no way we'd have gotten this far if proﬁt was in the driver's seat.’ says Druyan, who's carrying on her late husband’: legacy (her company, Cosmos Studios, is bankrolllng Cosmos 1 to the tune of $4 million). ‘You have to fund things that don't have an immediate or even obvious payoff, because, as anyone with even a casual acquaintance with science knows, very often when you're looking for one thing, you ﬁnd something else.’ The Cosmos I project is chock-full of Saganite elements: international cooperation. eco-friendly propulsion. and millions of people having a virtual exploration experience by tracking its movements on the Web. The swords-into-ploughshares element (the Russian rocket carrying Cosmos 1 was once pointed at an American city] in particular would have delighted Sagan. Ulti- mately, though, even if Cosmos I succeeds, behind the answers it provides will lie more questions, too many to count—and Saganites, being Saganit, will surely embrace every one. The Notion of One day using a solar-sail craft to carry I provisioned human payload on an interstellar mission comes with many sets of problems- not last of which is the need for solar sails so large they would be vulnerable to being shredded by cosmic debris.That doesn't deter Delory, though, because to him it's not essential that humans charge into space en masse, at least anytime soon.

### Solar sails are infeasible—science proves that they would overheat and not move

Gold 03 (Thomas-- professor of [astronomy](http://en.wikipedia.org/wiki/Astronomy) at [Cornell University](http://en.wikipedia.org/wiki/Cornell_University), a member of the U.S. [National Academy of Sciences](http://en.wikipedia.org/wiki/United_States_National_Academy_of_Sciences), and a Fellow of the [Royal Society](http://en.wikipedia.org/wiki/Royal_Society), “The solar sail and the mirror”, June 5, 2003, http://arxiv.org/html/physics/0306050)

The radiation pressure exerted by incoherent light on diverse surfaces is examined. The thermodynamic rule, first given by Carnot in 1824, describes the limitation to the amount of free energy that can be obtained from a source of thermal energy, and he gave the compelling reason for this rule, that if more free energy than he had prescribed could ever be extracted, then a heat pump could use that free energy and re-create all the heat energy that had been consumed. A perpetual motion machine could then be constructed. Now, 179 years later, it is proposed to fly a spacecraft that is expected to gain velocity from the radiation pressure the sunlight is expected to exert on solar sails, panels of thin plastic sheets, mirror surfaced on the side facing the sun. However a detailed examination of this proposal shows it to be in direct conflict with Carnot's rule, and no such pressure can be expected. Either Carnot's accepted rule is in error, or the solar sail proposal will not work at all. Carnot, a French engineer had described in 1824 a basic law of thermodynamics: heat energy can be converted into "free" energy, such as mechanical energy of motion, but only in an engine which must have certain properties. Heat must enter it at a temperature which we will call T1, and it must then be degraded in the engine to a lower temperature, T2. A certain fraction of this flow of heat energy can then be converted into free energy. The maximum fraction that can be so converted is given by (T1 - T2)/T1. He had shown that the cycle is reversible, so that a heat pump can be constructed that would use free energy to deliver heat; moreover that it would be able to reverse the heat flow from T1 to T2 precisely, if given the maximum free energy obtainable from the heat engine. Thus he showed that a perpetual motion machine could be constructed if either the heat engine or the heat pump could achieve a higher efficiency than that which he had stipulated. Any device that can obtain free energy from a supply of heat, by whatever means, is thus covered by Carnot's rule. 179 years have gone by during which all the heat engines we now employ for every aspect of our civilization have been designed, and all their designers have recognized Carnot's rule as the ultimate aim of their designs. The physicists of that long period have all agreed with that rule. Lord Kelvin based his deduction of the absolute zero of temperature on Carnot's considerations. The absence of perpetual motion machines seems to show that no one has succeeded in overcoming the limitations prescribed by Carnot. Yet now, we have a proposal on the table that runs counter to the rule of Carnot. It is proposed that the radiation pressure on a mirror from a hot body, the Sun, could be used to supply propulsion energy and momentum to a spacecraft, and thus facilitate interplanetary travel of vehicles, without the need for any other means of propulsion. What a desirable solution this would be! The Sun would pour out its energy whatever we do to it, and the momentum associated with that, calculated by Maxwell and confirmed later by Einstein, would be E/c, where E is the amount of energy emitted in a given interval of time, and c is the velocity of light. If a perfect mirror is used to receive the sunlight and its momentum, the re-emission of that light would gain the same momentum once more, and thus the force exerted on a perfect mirror would be doubled. The best mirrors are not completely perfect, but this would cause only a small loss of efficiency. It is proposed to use thin plastic sheet with aluminized mirror surfaces for these "solar sails". The speeds were calculated for a certain speeds of interplanetary travel to be obtained. A fund of several million dollars was assembled for the first space experiment of the new technology is proposed to be launched within a few months of writing this. But what will be the performance of the mirror as a heat engine? If the mirror receives heat energy from the Sun and converts some of this into free energy, namely the kinetic energy of its motion, it falls into the strict definition of a heat engine, and Carnot's rule defining the maximum efficiency for this energy conversion must apply. We can determine the incoming temperature of the radiation by measuring the temperature an absorbing (black) body would reach when exposed to the radiation being sent to the mirror, and the temperature a black body would reach exposed to the outgoing radiation from the mirror, both measurements carried out in common motion with the mirror. Carnot's rule would then give the maximum efficiency as that fraction of the heat flow trough the mirror, given by the difference of the two temperatures, divided by the input temperature. It would be that fraction of the heat flow that could maximally appear as kinetic energy gained by the mass of the mirror. If this was a perfect mirror, the two temperatures will be the same, and it follows that the mirror cannot act as a heat engine at all: no free energy can be obtained from the light. The proposed solar sail cannot be accelerated by sunlight

### Solar Sails fail when applied in space – imperfect sails due to solar radiation pressure, and deployment problems

Rizvi 10 **–** M.S./B.S. Concurrent Degree Candidate at the Department of Aerospace Engineering Sciences at the University of Colorado (Farheen, “Solar Sail Attitude Dynamics and Coning Control: On Developing Control Methods for Solar Sail Coning at Orbit Rate to Attain Desired Orbital Effects, 2010, <http://www.hanspeterschaub.info/work/Papers/grads/Rizvi_Farheen.pdf>)

I.2.3. Structural Analysis

In order to analyze solar sail attitude dynamics and control, accurate prediction of forces and moments acting on the sail are required. Most attitude control systems have been developed for a flat sail. An actual sail in orbit, however, billows out due to the solar radiation pressure. Such sail deformation alters the center of mass to center of pressure offset and thus modifies the resultant thrust force and moment acting on the sail. In a research study, a geometrically nonlinear finite element method is used to calculate force and moment exerted on an arbitrarily shaped solar sail subjected to solar radiation pressure [24]. In addition, it is shown that sail deformation due to solar pressure load can be approximated by deformations that are caused by corresponding uniform gas pressure load. This facilitates force and moment sail analysis via commercial finite element codes. With improved sail structural dynamics, force and moment predictions, more accurate attitude controller designs can be developed. Along with sail shape aberrations, sail surface quality degradation also affects sail attitude. Non-uniform sail reflective property and mass distribution give rise to unknown forces and moments to the control algorithms. A study to reveal how real, imperfect sails act as propulsion devices shows that surface quality errors result in an unacceptable mission profile when no initial calibration or on-the-fly corrections are made [3]. Thus, surface quality degradation prediction remains a difficult challenge. Apart from sail shape deformation and surface defects, sail deployment is also a concern. A challenge has been to study how folded sail membranes behave when deployed. The spacecraft structure houses the creased and packed sail until deployed in space. There is interest in the use of thin-film membrane structures for future gossamer spacecraft missions such as solar sails. Ultrasail (light weight, spinning solar sail) design relies on thin films for propulsion. The structure does not contain booms or masts, which significantly reduces mass and enables high payload fractions and accelerations [1]. A different study on a 500 mm x 500 mm thin-film membrane determined the shape of the deployed membrane and load displacement relationship for in-plane, diagonal loading of the sail corners [19]. Although the analytical analysis is 9 applicable to larger, sail-size membranes, it still remains inconclusive for sail deployment in space because the space environment torques and forces are not simulated. NASA’s advances in solar sail technology however simulated a more space-like environment. The NanoSail-D mission developed, deployed and conducted vacuum testing on two 20 m2 solar sail systems [4]. Although the mission never reached Earth orbit due to launch vehicle failures, NASA achieved advances toward these missions to develop, build and ground-test an innovative solar sail satellite

### Even if it didn’t, it would be impossible to absorb and deliver the momentum from the sun

Gold 03 (Thomas-- professor of [astronomy](http://en.wikipedia.org/wiki/Astronomy) at [Cornell University](http://en.wikipedia.org/wiki/Cornell_University), a member of the U.S. [National Academy of Sciences](http://en.wikipedia.org/wiki/United_States_National_Academy_of_Sciences), and a Fellow of the [Royal Society](http://en.wikipedia.org/wiki/Royal_Society), “The solar sail and the mirror”, June 5, 2003, http://arxiv.org/html/physics/0306050)

Would it be better to place a black sheet there instead of a mirror-faced one? Unlike the mirror, this could absorb energy and the momentum associated with that. But it would do this only from the moment of its exposure until it reached thermal equilibrium with the available radiation. Then energy absorption would cease, and with that the delivery of momentum to the sheet would also cease. For any lightweight sheet, this time would be only seconds. It seems that the failure to apply the thermodynamic limitations to radiation physics has shown up in many experiments involving radiation pressure. Thus Crookes' radiometer has invariably rotated in the opposite sense to the expected one. The black side of the paddles invariably recedes from the light, and many explanations have been offered, but not including that which would seem the most obvious: the absence of radiation pressure on the bright side. Similarly all attempts to observe a steady deflection of a pendulum exposed to a light beam have always only shown a brief effect following the sudden beginning of the illumination. Experimental evidence has been ignored and "explained away" each time as some unexpected artifact, because of the widespread belief that the conventional momentum conservation law must be correct. But this law was recognized by Newton only for material bodies, and he had no information about radiation effects. But the momentum conservation law can be shown not to apply to the interaction of radiation with any material objects. For example: take a black (light absorbing) body, initially at rest with a transmitter of radiation. Have the transmitter turn on a beam focused entirely on the body, for an interval during which the total amount of energy emitted is E. The momentum ascribed to this is then E/c, where c is the speed of light. If the entire energy E is used to accelerate the body, the kinetic energy it will then possess is given by 1/2(Mv^2) where M is the mass of the body, while the conservation of momentum with the radiation would have demanded an acceleration of the body to an energy content of Mvc, which is always more than 1/2(Mv^2)while the momentum of the radiation would have to accelerate the body to an energy content of Mvc. From a formal point of view, it is clear that one could not equate radiative momentum content with Newtonian momentum. Newtonian momentum is Mv, clearly a vector, while the momentum attributed to radiation is E/c, a scalar, since E is a scalar and c is a universal constant of nature. When an amount of energy E is captured as heat energy in a body from the light, this amount is thereby converted into a vectorial quantity, moving with the velocity of the body. It is only at this stage that this vectorial quantity can be compared with Newtonian momentum. How much of the radiant energy is absorbed depends not only on the amount of radiation that is directed towards the body, but also on the temperature of the body and the difference of that to the average radiation temperature striking it. This is defined as the temperature a black body would have when equilibrated in the radiation environment to which it is exposed. It is this consideration that brings the radiation result into compliance with Carnot's rule and thus with the amount of free energy that can be obtained from a source of heat. The mass added to the body is given by the equivalent relativistic mass of the energy absorbed, and the radiation pressure is the force we would deduce as necessary to change the momentum of the body by the observed amount. If the body is a perfect mirror or reflector of all incident energy, instead of a black body, then the energy absorbed is zero and so the radiation pressure is zero also. The same is true for any body, when it has reached temperature equilibrium with the radiation to which it is exposed.

## Prizes CP Solvency

### Substantially increasing award prizes is necessary to stimulate industry breakthroughs – solar sails are a crucial category of these awards

Morris 04(Jefferson, “NASA lobbying for authority to grant prizes above $250K,” Aerospace Daily & Defense Report, 11/16/04, lexisnexis)

NASA is lobbying Congress for the authority to award prizes of more than $250,000 in its Centennial Challenges program, and hopes to get a green light during the current lame-duck session of Congress or early next year. NASA needs authorization from Congress to award prizes of more than $250,000. Centennial Challenges Program Manager Brant Sponberg met with authorizers on Capitol Hill to discuss the issue Nov. 15. "There is some interest in maybe trying to pass something, either as a stand-alone bill or some other vehicle, during the lame-duck session," Sponberg said during an industry day in Washington Nov. 15. "Even if that doesn't happen, I would anticipate that when the new Congress comes in early next year, we [will] probably move out pretty quickly to try to get that authorization for those larger prizes." Modeled on successful 19th century navigation prizes and early 20th century aviation prizes, the Centennial Challenges prize program is aimed at stimulating industry to produce breakthroughs in technologies that would support NASA's goals. The agency requested $20 million for the program in fiscal year 2005. Although the House Appropriations Committee voted to fully fund the request, Senate appropriators only granted roughly half of it. "I don't know where the final negotiations will come out - somewhere between 10 and 20 million dollars, presumably," Sponberg said. The program already has roughly $2 million in FY '04 funds to begin awarding support contracts and small prizes. Four broad categories of challenges are planned: flagship challenges, keystone challenges, alliance challenges, and quest challenges. The biggest prizes offered by the program, flagship prizes will be worth $5-50 million. The program currently envisions four flagship competitions: \* Aero-assist demonstration. Although NASA spacecraft routinely use techniques such as aerobraking, "no one has actually demonstrated a true aerocapture or an orbital plane change using aero-effects in orbit," Sponberg said. Prize competitors will have to build a low-cost technology demonstrator to prove their technique in Earth orbit. Aero assist techniques use planetary atmospheres to help with orbital maneuvers. \* Micro re-entry vehicle. Competitors will have to build a low-cost automated vehicle capable of bringing small payloads down for accurate landings. NASA is interested in using such technology to improve science return from the space station. \* Lunar robotic soft landing. "The idea behind this prize is to stimulate someone to demonstrate the ability to softly land a small payload on the moon at low cost," Sponberg said. \* Stationkeeping solar sail. Competitors would have to build a solar sail capable of keeping a spacecraft in orbit for an extended period. NASA is interested in this technology for remote sensing and communications relay applications.

### Prizes could be used for solar sails—sparks competition that leads to innovation

Steidle 4. (Craig—Rear Admiral, Associate Administrator for Exploration Systems, NASA. 7/15/4. Hearing Before the Subcommittee on Space and Aeronautics, Committee on Science. *NASA CONTESTS AND PRIZES:* *HOW CAN THEY HELP ADVANCESPACE EXPLORATION?* http://commdocs.house.gov/committees/science/hsy94832.000/hsy94832\_0.HTM)

*To Leverage Partnering Opportunities—*These would be prize competitions for technical goals and capabilities that are common between NASA and other organizations. The size of the purses for these prize competitions would range from hundreds of thousands of dollars to a few million dollars. Partners would cost-share the purse with NASA or be responsible for competition administration. Partners could include: professional organizations, corporations and non-profit research organizations, other federal R&D agencies, hobbyist organizations, and public space advocacy groups. Examples include Challenges for: an autonomous, low mass drilling system for accessing underground science samples and resources on other worlds and on Earth; an improved power storage system for rovers and for various Earth-based applications; a fully autonomous unmanned aerial vehicle for cargo delivery; high strength-to-weight materials; and a solar sail mission to provide space weather data for various government customers.