Aerial floating in laser and microwave beams

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We propose and demonstrate the feasibility of using laser and microwave beams for aerial floating—to produce or increase the buoyant lifting force, and to employ radiometric or flare pressure to produce directed motion or directed lifting of objects floating in air.

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Different variants have been recently proposed for using laser beams to set bodies in motion and accelerate them to cosmic velocities under the influence of the optical evaporation back pressure in (proposed in[1] and realized in[2] in the case of macron acceleration, and proposed in[1] for satellite control and in[3–5] for laser acceleration of rockets), acceleration by pressure of a light flare or spark (proposed in[2] and developed for rockets in[4–6]), etc. Unfortunately, to set bodies of large mass into motion all these methods require gigantic powers and energy supplies unobtainable at the present time.

In the case, however, of devices that use the Archimedian buoyancy force, the laser beams required for lifting and controlling the motion have power and energy commensurate with the outputs of existing lasers.

In fact, if it is assumed that the volume $V(p,T)$ of the working medium depends on the pressure p and on the temperature T inside the shell, then we can estimate the change of the lifting force

$$\Delta F \approx \rho_0 g \Delta V,$$

where ρ_0 is the air density and g is the acceleration due to gravity. In the simplest case, when the pressure inside the shell changes little (soft or weakly elastic shell) we obtain

$$\Delta V \approx \left\{ \left[1 + \frac{Q(\gamma-1)}{p_0 V_0} \right]^{1/\gamma} - 1 \right\} V_0,$$

where Q is the energy release due to the absorption of radiation in the working gas, in the shell, or in the absorbing additives, sols, absorbing films or layers, etc.). Then

$$\Delta F \approx \rho_0 g V_0 \left\{ \left[1 + \frac{Q(\gamma-1)}{p_0 V_0} \right]^{1/\gamma} - 1 \right\} \approx \rho_0 g \frac{(\gamma-1)Q}{\gamma p_0} \quad \text{at} \quad Q(\gamma-1)/p_0 V_0 << 1,$$

where γ is the adiabatic coefficient of the gas inside the shell, i.e.,

$$\Delta F/Q \approx 5 \text{ dyn/J} \approx 5 \text{ g/kJ} \approx 5 \text{ kg/MJ}$$

Since the change of the volume force is usually applied to objects in which the weight is balanced by the lifting force, it is seen that even starting with energy outputs of tens and hundreds of kilojoules it is possible to control the lift or the descent of even large objects in a wide range. Such energy outputs can be produced in a pulsed or quasi-continuous regime, for example with the aid of gas lasers, gasdynamic lasers, chemical lasers, etc. For example, at a CO_2 laser power on the order of hundreds of kilowatts, exposures on the order of several seconds or dozens of seconds are sufficient. We note that the time of the loss of heat is quite large and increases sharply with increasing dimensions of the object, so that even smaller powers may be used for a prolonged time.

A demonstration experiment was set up aimed at controlling the lifting force. A sphere containing a gas lighter than air (helium, helium with the absorbing gas SF_6 as an additive) with volume $V = 10^4$ cm^3 and balanced by a small weight was placed in the path of a beam of a high-power pulsed laser[7] producing up to 3 kJ within ~1 μsec. The walls of the shell of the sphere absorbed weakly the laser radiation, but after the laser flash the sphere was lifted upward and its time of flight reached 30 sec before the sphere began to drop slowly. The sphere was lifted at a velocity 1.5—2 msec; by assuming that the velocity is proportional to effective force and by determining the weight that can make the sphere descend at the same velocity, we can estimate the lifting force and the energy released in the sphere. Estimates have shown that the lifting force was $\Delta F \sim 3$ g, corresponding to an absorption up to 600 J.

In addition to the buoyant force, it is also possible to produce lift and directe motion by means of the so-called radiometric force, which is due to ejection of the medium from the heated surface of the shell or of a special target, and also the gasdynamic pressure produced when a laser flare is ignited. In order of magnitude the pressure is $p \sim \rho_0 u^2$, where ρ_0 and u are the density and velocity of the gas ejected from the surface. In unfocused beams, these forces are too small to realize the tasks of[3–6], but are perfectly adequate in our case.

It is possible to ignite a flare discharge by focusing laser radiation on some initiator inside the shell by means of a mirror or by a metallized shell and to heat the working medium by such a flare.

Obviously, besides laser beams it is possible to use also powerful microwave beams for the control of the buoyant or radiometric force, i.e., it is possible to produce a "Kapitza ball lightning."[8]

The foregoing effects can increase the effectiveness of the lift and the maximum height of aerosonde or stratosphere balloons and control their flight from the ground. In particular, it is possible to increase the height of scientific baloons with light-weight recording photoemulsions or instruments, to produce strictly the vertical lift by using tubular beams or several beams that press the object toward the axis (the analog of the transportation in hollow beams proposed in[9]), etc.

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