SIMULTANEOUS EXTENDED ACTION OF A HIGH-POWER LIGHT BEAM ON MATTER

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The possibilities are considered of the simultaneous extended action on matter of a high-power laser beam focused by a cylindrical lens. A transverse linear spark, 3 cm long, was obtained in argon at a pressure of 10 atm. The possibilities are discussed and experiments are described in which such breakdown in a gas and on the surface of a dielectric is used to trigger fast-response dischargers. Consideration is given to the feasibility of generating short radiation pulses by the perturbation of external fields; of the strong modulation and reflection of microwave fields; of the propagation of a plasma front at a velocity higher than that of light, etc. Experiments are described in which linear apertures are pierced in metal plates by an unmodulated laser beam which is focused by a cylindrical lens.

A virtually simultaneous, extended action of a high-power light beam on matter is desirable in some experimental work and in certain applications. For example, such action is needed in the generation of plasma fronts moving at relativistic and faster-than-light velocities; in the establishment of rapidly growing plasma inhomogeneities, which scatter electromagnetic waves and perturb or bridge external fields; in the production of linear craters, etc. The present paper describes a study of such action of a laser beam focused by a cylindrical lens, and discusses the advantages of using two-dimensional beams which can provide simultaneous and extended action.

1. Linear breakdown by laser beam. Two-dimensional laser-induced breakdown in gases was investigated using a Q-switched neodymium laser. The laser beam was focused by a cylindrical lens of 6 cm focal length. The focal spot was located within a bomb filled with a gas at a pressure up to 20 atm. We used gases which broke down easily at high pressures, under low laser powers. This was desirable because the area of the focal spot of a cylindrical lens, $S_{f,cyl} \approx \varphi f l$, could be much larger than the area of the spot of an ordinary spherical lens $S_{f,sph} \approx (\varphi f)^2$. We found that $S_{cyl}/S_{sph} \approx 100$ for a laser beam of $\varphi \approx 3 \times 10^{-3}$ rad divergence and $l = 2$ cm width, focused by a lens of $f \approx 6$ cm focal length.

Figure 1 shows a photograph of the side view of a spark in argon kept at a pressure of 10 atm (dense filters were used to select only the brightest region of the spark).

Such a two-dimensional instantaneous spark could be used not only in the simulation of linear explosions and cylindrical shock waves but also in extremely rapid perturbation of external fields, especially in the rapid operation of high-voltage dischargers with large interelectrode gaps—desirable in the case of high working voltages (when the pressure is increased the breakdown voltage increases, but the threshold of the laser-induced breakdown decreases).

Experiments were carried out in which a discharge gap was bridged by such a linear spark in a gas, or by a linear jet discharge on the surface of a dielectric.

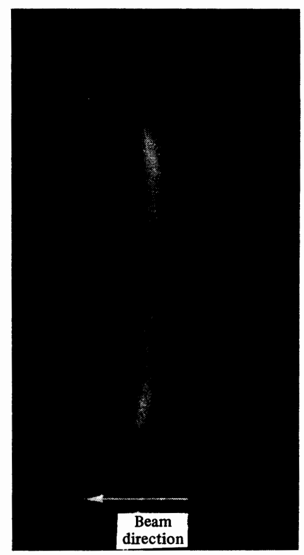

FIG. 1

When the focal line was made to coincide with the line joining the electrodes, the breakdown occurred rapidly at voltages much lower than the breakdown value.

A linear laser-induced spark in a gas, or on the surface of a dielectric, is a plasmoid with a faster-

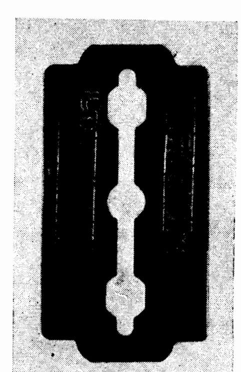

FIG. 2

than-light velocity of the breakdown front, which may be useful in microwave switches and modulators, as well as in generators of short pulses in the nanosecond and picosecond range.

2. Effect of a two-dimensional beam on a target. An unmodulated laser beam was focused by a cylindrical lens on a target. Figure 2 shows linear apertures with even edges, which were pierced in a razor blade by a laser beam of 20 J energy. Two-dimensional beams should make it possible to accelerate various treatments of materials (cutting or welding), and to produce internal cavities and marks, and so on without any need to move the beam or the object being treated.

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42