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## Asteroid redirection using synchronized femtosecond pulse trains

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We examine the use of multiple synchronized trains of energetic femtosecond duration optical pulses to redirect an asteroid discovered on short notice on collision course with Earth. We find such delivery entirely in the vacuum and microgravity of space can closely approach the maximum possible efficiency of redirection. Such efficiency would not be possible, e.g., in the atmosphere of Earth. This optimal application of the redirecting energy is, however, still challenging. One demanding requirement is precision of both location and timing of multiple ablation events using a minimum of three simultaneously delivered energetic femtosecond optical pulses for each ablation event. Another challenge is undesirable loss in optically absorbing ejecta generated by the focused optical pulses. These ejecta are an inherent complication of the ablative propulsive event. We find this source of loss which, however, appears largely avoidable by the use of a combination of sufficiently short duration optical pulses and optimal timing and positioning of delivery events. In addition, the average number of ablative propulsive events per unit time, which must be precisely timed and positioned, is large. We suggest that while such an engineering task appears extremely demanding, it can be achieved using currently evolving means of delivering large numbers of femtosecond pulses per unit time. We consider, specifically, the problem of redirecting a 10,000 metric ton asteroid such as the one that struck Earth near Chelyabinsk, Russia in 2013. We find, e.g., four months of precisely delivered optical energy at 10 kW average power could, at least in principle, have entirely prevented that collision.

### Biography

Richard Fork received a PhD in Physics from MIT in 1962. He worked as a Member of Technical Staff in the Quantum Electronics Department at AT&T Bell Laboratories from 1962 to 1990. He was a Professor in the Physics Department of Rensselaer Polytechnic Institute from 1990 to 1994 and is, currently (1994 to the present), a Professor in the Electrical and Computer Engineering Department at University of Alabama in Huntsville. He has over 150 published technical papers listed on Research Gate. These include the original demonstration of laser mode locking as well as a number of the original advances in generation and application of mode locked laser pulses. His inventions include the first optical pulse of 6 femtosecond duration and the colliding pulse laser, which was the first laser operating well into the femtosecond time regime.

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