ANALYSIS OF COLLISION AVOIDANCE VIA GROUND-BASED LASER MOMENTUM TRANSFER

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Abstract: There is little potential of action in case of conjunctions where neither chaser nor target can be controlled by spacecraft operators. Nevertheless, potential collisions between such objects pose a significant threat to the space debris environment. In view of that, some recent studies and developments addressed the concept of momentum transfer (MT) from ground-based lasers for orbit modification and, therefore, collision avoidance.

When exerting photon pressure during an object pass, the effective delta-V direction and magnitude is highly constrained and uncertain. Across different station passes, the cumulative effects may add up differently or may even partially cancel out in the conjunction plane (b-plane). Hence, momentum transfer strategies may differ, amongst others, subject to conjunction geometry and location, station passes and time to event, area-to-mass ratios and maximum laser power. Beyond that, tracking must be accurate and dense enough to reliably verify these small orbit modifications and to facilitate further MT actions with necessarily small laser beam widths.

In the face of these challenges, we study potentials and limitations by considering various MT network topologies as well as laser system characteristics. We perform our analyses statistically regarding station revisit times and pass geometries for a large set of potential conjunction scenarios. Our main contribution lies in the discussion of suitable MT strategies for collision avoidance. Amongst others, these comprise optimizing for the most suitable combinations of MT passes under constraints and uncertainty as well as deciding between MT during the ascending or descending arc of a pass. Eventually, reachability of separation in the b-plane is formulated in a control-theory-like manner.