Space debris – a problem with an optical solution

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Since the first launch of the Sputnik satellite in 1957 several thousand satellites have been deployed in the low earth orbit (LEO), i.e. with an altitude of several 100 km to 2000 km. Since the atmospheric drag is strongly reduced at higher altitudes, objects with altitudes above 500 km remain in orbit for tens to hundreds of years depending on their exact altitude. Hence many objects remain in space beyond their useful life. Additionally to disused satellites the population of smaller space debris particles is growing with an annual growth rate of approximately 5%. Major jumps in the population of space debris result from the collision of the Iridium 33 and the Kosmos 2252 satellite in 2009 as well as a Chinese anti-satellite missile test in 2007. The available data base for space debris in the LEO contains about 22000 objects with a size larger than 10 cm. Operational satellites represent only 6% of the orbital object population. 38% is attributed to large space debris such as derelict spacecraft and upper stages of launch vehicles, and mission-related items. The remaining 56% is attributed to more than 200 in-orbit fragmentations. The estimated number of smaller space debris in the size range from mm to several cm particles is in the range of 600000. Due to the high relative velocities larger than 8 km/s between active satellites and space debris, even small space debris particles pose a major thread to those satellites and space infrastructure such as the international space station (ISS). In certain altitudes the debris population is already at a value where the transition to cascading, also known as the Kessler scenario, might set in.

At the Institute of Technical Physics of the German Aerospace Center (DLR) we develop optical means to detect space debris and determine accurately the trajectory of debris particles. For the determination of space debris trajectories we use laser based ranging and tracking with pulsed infrared lasers in the atmospheric window at 1 µm wavelength. By employing ns pulses with 100 µJ of energy we detect single returning photons reflected from satellites or larger space debris particles. From accurate timing measurements we determine trajectories in three dimensions with an accuracy of several meters at a distance of 1000 km. The transition towards lasers with larger pulse energies and shorter pulse length will enable to track smaller particles as well in the future. These information will be fed to a data base for space debris. A high accuracy of such data is of high importance in order to schedule avoidance maneuvers of active satellites. In the talk we will present the details of technical laser-based space debris monitoring.

Finally, we will discuss the issue of space debris mitigation. One strategy is to avoid the future increase of space debris by international guidelines as published by the Committee on the Peaceful Uses of Outer Space (COPUOS). However, these guidelines will not help to solve the existing problem with the actual debris. Among several concepts, one concept is based on the application of high power laser pulses in order to modify the trajectory of smaller debris particles via laser ablation. The requirements and feasibility of this approach will be discussed.