Optical choppers:
Novel developments and an insight in biomedical applications

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We report our one-decade contributions regarding developments of optical choppers. One of the most common devices in optics and photonics (almost as utilized as lenses, mirrors, and prisms), a classical chopper is essentially a rotational disk with a certain number of windows (and wings) that stops with a corresponding frequency a light (usually, laser) beam. Choppers are employed for the attenuation of light, to eliminate certain wavelengths or spectral intervals, or to produce light (laser) impulses of certain frequencies and profiles [1]. For the latter, laser impulses produced by disk choppers have been usually considered as rectangular, but this is valid only when the beam is perfectly focused in the disk plane. We approached the actual non-linear profiles of laser impulses produced, by performing a multi-parameter theoretical analysis that considered all possible relationships between the dimensions of the disk and of a top-hat transmitted beam (i.e., with a constant intensity on its section) [2]. This theory was confirmed by other groups experimentally [3]. This is the first part of this discussion.

The second part presents the development of novel configurations of disk choppers [4-6]. While classical disks have windows with linear margins, we have introduced [4] and patented [5] chopper disks with windows with non-linear (e.g., semi-circular) margins. We have proposed for them the name of '*eclipse choppers*', because of the way the semi-circular margins obscure the beam section, similarly to a planetary eclipse. The transmission functions of eclipse choppers are the general case of those of classical disk choppers, because the latter can be obtained as a particular case of the former by considering the radius of the window margins going to infinity [6].

While these eclipse choppers can thus produce other profiles of laser impulses (for example, approximately triangular) in comparison to classical choppers, their chop frequency (i.e., the frequency of the generated laser impulses) is similar, limited in the literature to 10 kHz [1], although vibration issues already appear around 3 kHz. A direction of research to address this issue has been to develop Micro-Electro-Mechanical Systems (MEMS) choppers [7]. Due to technological and cost limitation of MEMS, we have however taken another path, by developing macro-choppers with (fast) rotational shafts of different shapes (cylindrical, spherical, or conical) and with various shafts profiles-patent application [8]. The third part of this presentation points out optical, as well as mechanical aspects of these novel devices [9].

Finally, from the various applications of choppers, we present biomedical imaging ones, using conjugated Optical Coherence Tomography (OCT) and Confocal Microscopy (CM) [10].

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