Editorial

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This Special Issue of the CEAS Space Journal introduces Optics as a new field of technology and applications to be covered by the Journal. It is largely based on contributions presented in the last International Conference on Space Optics—ICSO—held in October 2016 in Biarritz, France.

ICSO is the largest multidisciplinary meeting on optical engineering in Space held every 2 years and a prime event for reporting all the advancements on the field especially in Europe. We thank the authors for providing thorough contributions on their work and the reviewers for their diligent work that helped to improve the submitted manuscripts.

The contributions presented in the Special Issue on Space Optics include first papers on optical instruments, then papers on optoelectronics, i.e., lasers and photodetectors, and conclude with papers related to microphotonics and optical wireless technologies. The issue is structured accordingly.

The first paper is strictly related to the scientific discovery of the year, honored by the Physics Nobel Prize, which is the first detection of gravitational waves. This great result has probably been the most challenging technological achievement of the century because of the minuteness of the observable quantities and the extremely stringent requirements on measurement accuracy. Now, to get still better results and to open new opportunities to observe the universe in this still unexplored window, the next step will be to bring this measurement on space. In this Special Issue, the proposed Japanese mission DECIGO, a three-satellite formation linked

to form a 1000-km laser interferometer, and its precursor B-DECIGO are described, providing some indications about the incredible requirements that have to be satisfied for getting still better measurements with this novel technique. Notice that one of the most important submodules of the space segment is the laser which has to provide cutting-edge stability for both intensity and frequency. This is dealt with in a separate paper related to DECIGO/B-DECIGO, which can be found in the Optoelectronics part of this Issue.

The following paper is a very detailed description of ARIEL, one of the remaining three candidate missions for the ESA Cosmic Vision M4 call, after the initial selection over 25 different proposals. ARIEL is a 1-m class telescope dedicated to observe in the infrared the atmosphere of known transiting exo-planets, for understanding their physics and chemistry and for verifying the possibility of hosting life-forms. The selection of the M4 mission, whose launch is foreseen in 2026, is a very actual topic, as it is expected in just a few weeks.

Another topic which is becoming increasingly important for Earth observation and planetary research is the development of Fourier transform spectrometers in the infrared spectral range (FTIR). In this context, this Special Issue includes a contribution that deals with recent technological developments on this field to come up with improved spectrometers with respect to spectral range and resolution. The TIRVIM Fourier spectrometer is part of the spectroscopic suite that currently is part of the ExoMars TraceGas Orbiter launched in 2016. Also, instrumental and conceptual developments for the Luna Resource Orbiter and ExoMars Surface Platform both planned for 2020 are described.

Then, we will move to an example of what is presently revolutionizing space science and space applications, which is the possibility of instrument miniaturization for fitting in nanosatellite clusters. In this case, NanoVipa is a high-resolution echelle spectrometer for star observation installed just in a 6U platform. This paper not only shows the great novelty of being able to miniaturize such an instrument type, usually a very complex one, but also it shows that it is possible to make astronomical science by means of nanosatellites:

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this demonstrates the great versatility of nanosatellites and opens additional new development perspectives for this technological and scientific sector.

Following this section dedicated to space missions and the relative optical instrumentation, in the Optics part of this Special Issue, we publish three papers dedicated to technological development on space optics sub-systems. In particular, we will see the most recent design and manufacturing of an image slicer field unit, made of an array of 45 micro-mirrors with incredible levels of surface roughness and optical quality useful for visible light spectroscopy, developed for the Japanese Solar-C mission.

Another paper is dedicated to the realization of GRISM elements (a grating patterned on a prism surface to have a diffracted beam along the same direction of the incident light beam) by means of a new technology of hydrophilic direct bonding. The whole manufacturing process is described, demonstrating the extremely performing opto-mechanical properties under space conditions of these optical devices.

The third paper of this section shows a very complete and detailed study for designing complex, very narrow band-pass optical interference filters for a possible use on MetOp second generation 3MI instrument. The filter coatings have been realized using the novel plasma-assisted reactive magnetron sputtering technique, demonstrating excellent agreement between theoretical and experimental performance.

Then, we will see a pair of papers dedicated to space optical instrument calibration. The first is the description of a novel technique used for testing the performance of an ellipsoidal mirror with central hole for the METIS solar coronagraph on board of the ESA Solar Orbiter mission. We should remember here the challenges of making a solar coronagraph, that has to block the sun disk light by more than nine order of magnitudes (in visible light) to allow to see the solar corona with a good signal to noise ratio. This implies a series of extremely stringent requirements on several optical parameters. The new technique described in this paper allows getting an accurate and fast wavefront measurement also with the mirror already integrated in its mounting structure.

The second calibration paper describes the technique adopted for aligning the PILOT off-axis Gregorian telescope. The latter is a balloon-borne astronomy experiment for studying the interstellar dust polarization in the thermal infrared, with the main challenge of having all the optics in a 3-K cryostat, with the exception of the primary telescope mirror. To get the instrument properly aligned, optical and three-dimensional measurements have been combined with the expectations provided by a thermo-elastic telescope modeling. All the processes are described, and the results obtained with the first flight confirmed the goodness of the adopted procedure.

Finally, we conclude the optics part of this Special Issue with a modeling paper useful to predict scattering losses of

space optical components, especially when complex optical coatings are used. The problem arises when the scattering pattern exhibits spectral and angular lobes which can alter the expected final optical coating performance. In this paper, a specific model is described which accounts for all the involved parameters, and provides numerical results which are in good agreement with metrological ones.

The second part of the Special Issue deals with optoelectronics and includes two papers on lasers sources and two on photodetector technologies. The first of these papers takes us back to the first paper of the Special Issue and deals with the development of highly frequency and intensity stabilized lasers for space gravitational wave detector DECIGO/B-DECIGO, one of the main thrusts in space-borne Space Science missions.

Similarly with space science, earth observation using active remote sensing with LIDAR (light detection and ranging) is becoming more and more important since the successful implementation of NASA's CALIPSO mission and the upcoming ESA Earth Explorer missions Aeolus and EarthCare (the latter as a joint undertaking of ESA and JAXA). There is a lot of prospect for the remote sensing of greenhouse gases with LIDAR, since they show distinct advantages over passive optical sensors. This, however, imposes stringent requirements for a variety of sub-systems such as lasers and detectors. A wavelength range, which is particularly well adapted to the sensing of CO₂ is around 2 μm . There are two contributions within this Special Issue on related technologies covering both the transmit and the receive side of a LIDAR system operating at 2 μm . The first deals with a novel scheme for the stabilization of lasers to a CO₂ absorption line in the 2- μm range. This scheme uses hollow-core optical fibers and consists of an all-fiber design which is robust and therefore well-suited for space applications. The second paper is about an experimental investigation on avalanche photodiodes (APDs) using the promising material mercury cadmium telluride (HCT) and its application in a ground-based CO₂ LIDAR operating at 2.05 μm .

The last paper in the optoelectronics part covers the design and development of mixed-signal application-specific integrated circuits (ASICs) for space applications. The devices generate all of the signals required for operating and sampling data produced by CCD-based cameras. The work presented covers more than 10 years of development and in particular, focuses on recent improvements regarding performance and tolerance to radiation-induced single event latchup of a CCD video processing ASIC that was originally developed for NASA's Solar Terrestrial Relations Observatory and Solar Dynamics Observatory. The performance of a CCD bias voltage ASIC and a CCD clock driver ASIC is also described. The devices enable various CCD bias levels and clock parameters to be programmed independently and the authors discuss the impact and importance of this

technology for the development of compact, high-performance and low-power integrated focal plane electronics in the future.

The Special Issue concludes with two papers on the novel technologies of microphotonics and on optical wireless.

Microphotonics represent a new thrust for lightwave technologies, as there is a migration from “discrete photonics” to “integrated photonics”. In the paper by the team from the University of Gent and Antwerp Space, a novel approach to implement a frequency downconverter for Communication Satellite Payloads—COMSAT PLs—is presented. It is based on the so-called “hybrid integration” approach to allow miniaturization of both passive and active photonic parts. It is exemplary of the efforts pursued in implementing COMSAT PL equipment based on microphotonics with reduced mass–volume–power consumption and with increased functionalities, a challenge that will be a subject of intense research and development work in the coming years.

The last contribution to this Special Issue is a paper by INTA and ISDEFE where the flight demonstration of the optical wireless technology on board the OPTOS cube-sat is presented. This demonstration reflects more than 15 years

of efforts on space-borne diffused optical wireless at the near infrared band. As such, it provides a unique experience to be evaluated by S/C manufacturers for its merits both as an optical ground support equipment as well as a platform technology as the authors suggest.

Concluding the presentation of this Special Issue, we would like to acknowledge the pivotal work of the ICSO co-chairs Dr Bruno Cugny of CNES and Dr Zoran Sodnik of ESA. It is the increasing importance that ICSO has acquired within the space community over the past years that lead us to propose the Space Optics as a new topic for the CEAS Space Journal.

We truly hope that this first ever Special Issue on Space Optics of the CEAS Space Journal will make an interesting and inspiring reading!

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