光学天文技术
领域动态

2020 年第 1 期（总第 2 期） 2020 年 10 月

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本期概要：
本期动态专题扫描了 2020 年以来天文光学干涉测量方向的论文发表情况。

【研究动态：天文光学干涉测量】

本期动态专题扫描了光学技术方面最新研究动态。

✧ Optical Long Baseline Interferometer

1.	**Astronomers find closest black hole to Earth, hiding in plain sight** science doi:10.1126/science.abc6442 **Abstract -** Thomas Rivinius, an astronomer with the European Southern Observatory (ESO), and his colleagues studied the unusual star system HR 6819 in this way using a 2.2-meter telescope in Chile, operated by ESO and the Max Planck Society. They thought it was a binary system, but there was an extra wobble in the periodic light shifts of one of the stars that indicated something else was asserting its presence. It turned out to be a triple system, with one star in a fast 40-day orbit with an unseen companion and another star on a more distant, slow-moving trajectory, they write today in Astronomy & Astrophysics. The invisible companion's mass was large enough—four times the mass of the Sun—that, if it was a star, "we would have seen it," Rivinius says. To be sure the companion is a black hole, the researchers will take a closer look at the system. The team has applied for time to use ESO's optical interferometer, a device that combines the light of separate telescopes to achieve the resolution of a much larger one. "We wouldn't see the black hole," Rivinius says, but they should see one of the stars "orbit something else that's not there."

✧ Optical Synthesis Aperture

1.	**Analysis on angular field of view of holographic image dependent on hologram numerical aperture in holographic display**

	Byung Chae Optical Engineering Vol. 59, Issue 3 (Mar 2020) **Abstract -** We investigate the angular field of view (AFOV) of a holographic image reconstructed from the digital Fresnel hologram in holographic display. The theoretical analysis clarifies that the AFOV of a holographic image is fundamentally determined by the hologram numerical aperture (HNA) other than a diffraction angle of pixel pitch of a pixelated modulator. This property is proved for various types of the digital holograms using a numerical simulation and optical experiments. The high-HNA hologram reconstructs the image with a high viewing angle, whereas the image contraction is inevitable due to the Nyquist sampling criterion in the hologram synthesis. We demonstrate the method for reconstructing the holographic image with a high viewing angle without image contraction.

【会议扫描：天文光学干涉测量】

天文光学干涉测量

✧ Optical Interferometry for Astronomy

1.	**The impact of Roland Shack's wavefront sensor on the development of modern active optics** Proceedings Volume 11479, Roland V. Shack Memorial Session: A Celebration of One of the Great Teachers of Optical Aberration Theory; 1147908 (2020) https://doi.org/10.1117/12.2570773 **Abstract -** This paper discusses the impact that Roland Shack and his eponymous wavefront sensor have had on the development of active optics in astronomy. There are a number of interesting threads to this

	story, from the early concept development and its drivers, to the uptake and realization by the broader astronomical community of the advantages offered by this system. Shack's innovation not only directly benefited numerous large-scale astronomical projects, but it can be shown to have further inspired innovation, proving yet again that the "intangible benefits" of technical innovation are often themselves significant considerations. Another interesting aspect of this story is that via a quite distinct line of investigation initiated by Shack in the 1970's, an important conceptual omission in the application of the wavefront sensor to the first generation of active telescopes was recognized, and resultant improvements have further enabled a new generation of active telescopes and in particular wide-field survey telescopes.

✧ Optical Long Baseline Interferometer

1.	**An approach to upgrading the beam transport system at the Navy Precision Optical Interferometer** James Clark, F. Ernesto Penado, Sergio Restaino, Henrique Schmitt Proc. SPIE. 11488, Optical System Alignment, Tolerancing, and Verification XIII **Abstract -** We present an approach to upgrading the beam transport system at the Navy Precision Optical Interferometer. These upgrades together will provide consistent beam transport, improve fringe contrast by preserving beam wavefront, reduce tracking errors by increasing the frequency response of the tracker, and automatically realign the entire transport train after thermal drift over the course of nightly observations. The beam transport system passively redirects stellar light from the telescope output to the fast delay line through a train of flat mirrors. This multi-mirror transport train reduces wavefront preservation due to stack-up of surface flatness errors. We demonstrated previously by using a contour-conformable mirror instead of one of the flats in the train that a 63% improvement in wavefront flatness is achievable. Also, the 25 Hz tracker is replaced by a 100 Hz tracker to further stabilize the trajectory during observations. Finally, we include an auto-aligner to

	systematically realign the entire beam transport system from thermal drifts. This is necessary for long baseline interferometry with short drift time constants. The beam transport system is common to all front ends (telescopes and siderostats), beam delay, and back-ends (beam combiners and detectors). These three upgrades expand the utility of the NPOI from a relatively short 97 m baseline interferometer to its full reconfigurable 437 m baselines and allow consistent beam transport with various potential experimental telescope front ends and beam combiner back-ends. In this paper, we describe our three-pronged upgrade approach, experimental method and results, and recommendations.

✧ Optical Synthesis Aperture

1.	**Betelgeuse scope: single-mode-fibers-assisted optical interferometer design for dedicated stellar activity monitoring** Narsireddy Anugu, Katie Morzinski, Josh Eisner, Ewan Douglas, Dan Marrone, Steve Ertel, Sebastiaan Haffert, Oscar Montoya, Jordan Stone, Stefan Kraus, John Monnier, Jean-Baptiste Le Bouquin, Jean-Philippe Berger, Julien Woillez, Miguel Montargès Proc. SPIE. 11490, Interferometry XX **Abstract -** Betelgeuse has experienced a sudden shift in its brightness and dimmed mysteriously. This is likely caused by a hot blob of plasma ejected from Betelgeuse and then cooled to obscuring dust. If true, it is a remarkable opportunity to directly witness the formation of dust around a red supergiant star. Today's optical telescope facilities are not optimized for monitoring the Betelgeuse surface, so in this work, we propose a low-cost optical interferometer. The facility will consist of 12 x 4 inch optical telescopes mounted to the surface of a large radio dish for model-independent aperture synthesis imaging; polarization-maintaining single-mode fibers will carry the coherent beams from the individual optical telescopes to an all-in-one beam combiner. A fast steering mirror assisted fiber injection system guides the flux into fibers. A metrology system senses vibration-induced

	piston errors in optical fibers, and these errors are corrected using fast-steering delay lines. We will present the design.
2.	**Sub-wavelength holographic lithography (SWHL)** M. Borisov, D. Chelubeev, V. Chernik, V. Rakhovskiy, A. Shamaev Proc. SPIE. 11324, Novel Patterning Technologies for Semiconductors, MEMS/NEMS and MOEMS 2020 **Abstract -** Since the 1970s, the cost of photolithography in IC manufacturing has reached nearly 70% of the total production cost. The cost of production lithography equipment has grown almost 160 times reaching ~$80M (193i scanner) and exceeding $200M (EUV scanner). Such high costs have caused a significant market concentration in equipment and chip manufacturing. Historically, the projection exposure technology was developed on the foundation of geometrical optics. A projection mask was a magnified stencil of the projected pattern. To achieve resolution, extensive development efforts have been made to increase the projection optics numerical aperture (NA), reduce exposure wavelength, minimize distortions of the projection lens and destructive diffraction effects. Complicated and highly costly RETs (OPC, PSM, SMO etc.) are used to suppress distortions in the pattern image induced by diffraction and aberrations of the projection optics. Sub-Wavelength Holographic Lithography (SWHL) is an unconventional imaging approach in photolithography that utilizes diffraction and interference effects to create high-quality images in photoresist, whilst decreasing exposure steps' cost, including higher resolution nodes. The ability to construct arbitrary wavefronts opens multiple opportunities like printing on various 3-D surfaces. The SWHL is capable of dramatic reduction of the lithography cost and opens new opportunities in 3D imaging. Two proof-of-concept exposure systems were designed and built to verify the SWHL capabilities: the first for imaging patterns with sub-wavelength resolution, the second for printing on 3D surfaces. The fidelity and computation efficiency of mask synthesis and RET algorithms were verified.