UCF CREOL & FPCE
The College of Optics and Photonics

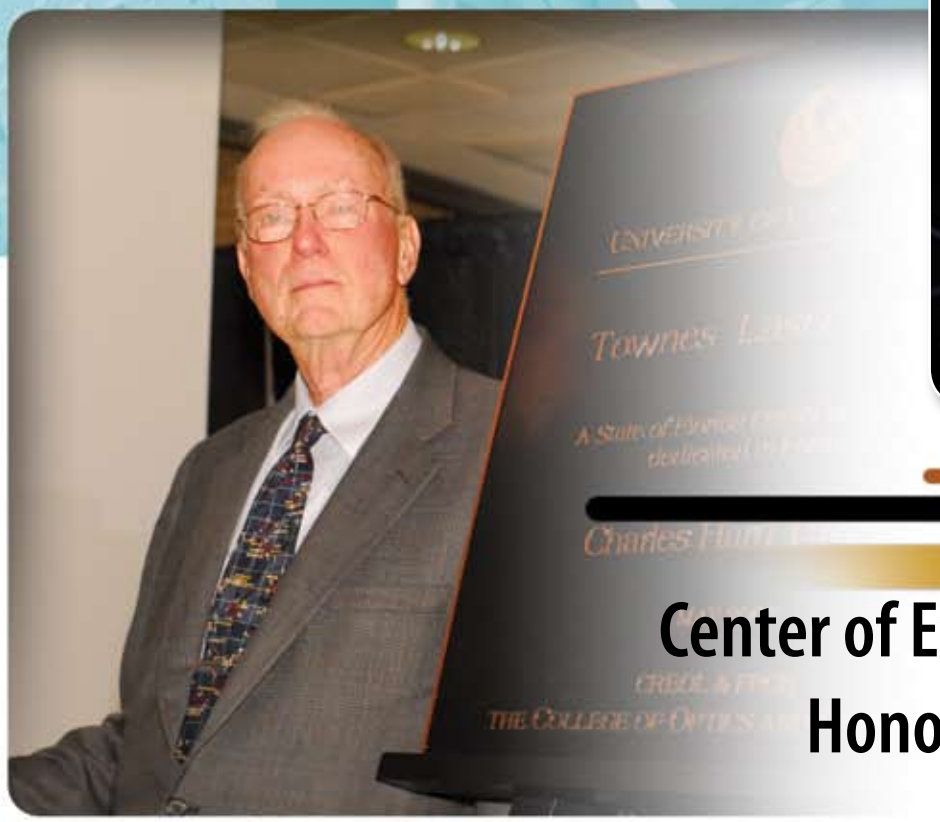
July 2007

Creating the Future of Optics and Photonics

Highlights

Academics • Research • Partnerships

Inside



Center of Excellence Named in Honor of Charles Townes

by Chad Binette
UCF News and Information

On May 3, CREOL, The College of Optics and Photonics, dedicated its new Center of Excellence in advanced laser technology in honor of Charles Townes, the laser's founding father; and announced a new fellowship in the name of Townes' wife, Frances.

Before the formal dedication of the Townes Laser Institute, Townes gave a lecture on the past, present and possible future of lasers, and he ate lunch with 83 students.

"It was great meeting the person who started it all," said Tim McComb, a doctoral student who works in Professor Martin Richardson's laboratory at CREOL. "It was kind of the same thing as someone meeting Thomas Edison in the 1900s. He started the electronic age. Dr. Townes started the photonics age."

Five decades after Townes conducted the research that led to the creation of the first laser, lasers can be found in virtually every aspect of society, including communications, surgery, computers and defense. A Nobel laureate himself, Townes said 18 Nobel Prizes have been awarded for work related to the laser and his earlier invention, the maser.

Richardson came up with the idea to name the new institute in Townes' honor, and he received the support of college Dean Eric Van Stryland, Provost Terry Hickey, President John Hitt and the Board of Trustees.

UCF also awarded Townes an honorary doctoral degree during a commencement ceremony on Saturday,

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Dean's Corner

Eric W. Van Stryland
Dean and Director

It's been a busy time! We just held our inauguration of the "Townes Laser Institute" which was truly a grand affair. You can see some more details on the front page. It was an amazing experience to get to know both Charles and Frances Townes – what energy! And hearing Charles' stories about the history of the laser was fascinating. We are all honored to be able to use his name for our new center which was initiated by new funding from Florida's Center of Excellence program. I personally want to thank Martin Richardson for all the work he put into making this happen.

And, I just returned from CLEO in Baltimore where we held a somewhat impromptu reunion at a local pub and I would guess we had >70 people show up for a great time (at least that's what the beer bill looks like)! I've included a couple of photos. Everyone tells me how important these are to keep in contact. But let me remind everyone to update their profiles on our website under [Alumni] and keep in touch by e-mail.

Since the last Highlights, we also have moved into our new building addition although we are saving much of this space for the ~8 faculty members we plan on hiring during the next 5 years! Hopefully this growth in faculty along with new space and all the activity will help to entice someone to take the Dean's position (a gentle reminder that I need to be replaced)! We gave tours of the addition at our recent Affiliates Day where we had a great assemblage of invited speakers. See Jim Pearson's article on page 3 for details and photos.

The following day we had our traditional Spring Thing picnic which went well as always. This year we had a Texas theme, celebrating the 20 years since several of us arrived from Texas to move into a double-wide trailer on the site of the current CREOL building! I count my anniversary from May 4, 1987, since that's when I left CLEO in Baltimore early to close on the house I still live in here!

Let me also thank Bruce Chai, President and CEO of Crystal Photonics in Sanford who was a faculty member of CREOL for many years, for donating a SEM to CREOL which will be housed in the CREOL building near our clean room. This is a very nice addition which will extend our capabilities in nanophotonics. Thanks Bruce!

As it is the beginning of summer, it is also the time when undergraduate students who are part of our Research Experience for Undergraduates (REU) program, funded by the National Science Foundation, show up to do research with faculty and graduate students at CREOL. This is a great program and has also turned into an excellent recruiting tool since we have had several of these excellent undergraduates return as graduate students. We will also soon be seeing students from overseas as part of our international REU program also funded by the NSF. Summer is a fun time to get lots of research done!

And speaking of working with the graduate students – they have outdone themselves recently with many awards and scholarships. See Student News on page 7 for all the details.


Alumni Reunion


Alumni Reunion


Spring Thing


Affiliates Day Reception

Affiliates Day 2007
Thank You to all of our Affiliate Members

ReCap

This year's Industrial Affiliates Day event was held April 13, as usual at the end of the week of SPIE's Defense and Security Symposium in Orlando. Although titled "Industrial Affiliates Day", the entire optics and photonics community is invited and welcomed to join us for this full day of presentations, lab tours, and posters designed to highlight some new and exciting developments in optics and photonics and to showcase the research at CREOL & FPCE, The College of Optics & Photonics. This year, over 250 registrants participated, from Affiliates member companies, other companies, special invited guests, and UCF.

L to R: M. Richardson, P. Corkum, S. Cundiff, E. Van Stryland, P. Delfyett

This year's program theme was "Ultra-Short Pulse Lasers & Applications". Some pictures of the day's activities can be viewed, along with the presentations outlined below, at http://www.optics.ucf.edu/people/affiliates/AffiliatesDay2006/.

Left: Nathan Bickel, Best Poster
Right: Student of the Year - Ying Zhou

Dr. Martin Richardson, Northrop Grumman Professor of X-ray Photonics at CREOL & FPCE, The College of Optics & Photonics, gave the opening talk on "High power lasers, some applications, and their future at UCF".

Dr. Paul Corkum, Program Leader, Atomic, Molecular & Optical Science (AMOS); Steacie Inst. for Molecular Sciences; CNRC spoke on "Attosecond Science and Technology" and described the development of technologies for producing and measuring attosecond laser pulses (1 attosecond = 10^{-18} second), noting that the current record for the shortest pulse is 130 attosec.

Dr. Michael Cumbo, Chief Operating Officer of Raydiance, Inc., described the work being done at Raydiance that is commercializing CREOL technology to produce a reliable, compact, affordable, and easy-to-use programmable ultra-short pulse laser platform with flexible optical performance specifications. He outlined how this type of commercial device is opening vast, previously unserved medical, dental, and life science markets to laser systems.

Dr. Steven Cundiff, Chief, Quantum Physics Division, National Institute of Standards and Technology, JILA; University of Colorado-Boulder presented results of work at JILA on "Pulse Dynamics in Mode-locked Lasers and the Linewidth of Femtosecond Combs". He described how such lasers can be used to study nonlinear pulse dynamics, providing a unique opportunity to test many aspects of soliton theory, and how development of femtosecond combs and their use for precision optical frequency metrology has provided a new impetus for further developments in the theory of mode-locked lasers.

The final invited talk was given by Dr. Peter Delfyett, Trustee Chair Professor of Optics, ECE, & Physics at CREOL & FPCE, The College of Optics and Photonics. In his presentation on "Stabilized Ultrafast Pulse Generation and Optical Frequency Combs – Techniques and Applications", Dr. Delfyett outlined how the development of stabilized modelocked lasers has enabled unprecedented advances in ultrafast optical sciences and in the resolution in metrology applications.

The afternoon program began with a formal dedication of the new 21,000 ft^2 addition to the CREOL building. Dr. MJ Soileau, Founding Director of CREOL and now VP for Research at UCF, outlined the plans for the new addition, which includes offices and labs that will be an on-campus extension of the UCF Technology Incubator. They also thanked the many contributors to the funding of the much-needed addition, including the Department of Commerce's Economic Development Administration, the Florida High Tech Corridor, and a long list of individual donors.

Following the building dedication, Eric Van Stryland, Dean of the College, provided an overview of all the research at the College, and Ms. Ying Zhou, winner of the CREOL Student of the Year Award and a graduate student working with Dr.Shin-Tson Wu, gave a presentation on her research entitled "High performance cholesteric liquid

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LASER CENTER from Cover

May 5. At that ceremony, Townes addressed graduates of the College of Optics and Photonics, College of Engineering and Computer Science and Rosen College of Hospitality Management.

The state provided $4.5 million to help fund the Townes Laser Institute, which will focus on the next generation of laser technologies for medicine, advanced manufacturing tools and defense. In addition, UCF will hire six new faculty members and will contribute more than $3 million for equipment and start-up costs.

Townes, 91, received the Nobel Prize in Physics in 1964 for developing the fundamental inventions that led to the laser. He has worked as a professor at the University of California at Berkeley since 1967, although he doesn't call it "work."

"I practically never work," he told more than 200 people who packed UCF's Harris Corporation Engineering Center auditorium. "I just have a great time doing science."

Townes said many people, including his department chair, doubted his research would succeed. But he was confident that he could, so he and his students pressed forward despite their critics.

"Fortunately, I was an associate professor with tenure, so they couldn't fire me," he said.

Townes won the Nobel Prize for two inventions, the maser and the laser. Maser stands for microwave amplification by stimulated emission of radiation, and laser is short for light amplification by stimulated emission of radiation. Townes and his research team coined both of those phrases.

In early 1954, Townes and his team achieved the first amplification and generation of electromagnetic waves by stimulated emission. They later published a paper showing that even shorter wavelengths, in the optical and infrared region, could be used. That theory led to the creation of the first laser.

At the dedication ceremony for the Townes Laser Institute, Van Stryland and Richardson unveiled a plaque that will be installed at CREOL. Richardson also announced the creation of a new fellowship honoring Townes' wife, Frances. That fellowship will be awarded to outstanding female students who are from underprivileged backgrounds.

"The College of Optics and Photonics is recognized the world over because of our faculty accomplishments," said M.J. Soileau, UCF's vice president for Research. "We would not be here today without Professor Townes' pioneering work."

Richardson recalled meeting Townes as a young scientist when he visited Berkeley in 1967, and he thanked Townes for inspiring him. Richardson also told Townes that everyone at CREOL is committed to ensuring "that the laser activities here will be at the top level of any academic institution in the world. We will keep it that way."

AFFILIATES DAY from pg. 3

crystal lasers". The afternoon was rounded out by graduate student research poster presentations, and tours of the laboratory facilities, expertly organized as usual by the CREOL Association of Optics Students – CAOS. Fifteen Industrial Affiliates had tabletop exhibits of their company's products.

The day concluded with a reception and the presentation of the Best Poster award going to Mr. Nathan Bickel, a student of Dr. Patrick LiKamWa, for his poster on "Nanofabrication of Quantum Boxes by Deep Etching of Multiple Quantum Well Structures."

Spring Thing 2007

Those who have attended previous Industrial Affiliates Day events know that, as enjoyable as IA Day is, the next-day's event is also a must-attend: The Spring Thing, hosted by MJ and Cheryl Soileau at their home on Lake Jesup that they have dubbed "Soggy Acres". For those who missed either of these great events, be sure to get IA Day 2008 and The Spring Thing on your calendar for next year! The festivities included great food, great fellowship, and a celebration of the 20th anniversary of "The Arrival of the Texans" when MJ, Eric Van Stryland, Dave Hagan, and their graduate students and a moving van of equipment arrived from their previous home at North Texas State University to start CREOL at UCF. Other fun activities of the day included:

- Grain products (solid and liquid!) and Cajun Cuisine cooked in grand style by Cajun Master Chefs: Gator, Pig, Chicken (tastes just like gator), miscellaneous good (and some healthy) stuff
- Eating, drinking and being merry!
- Country line dancing, led by Jim & Nanci Pearson
- Steer (simulated) roping, led by Ed Schons
- Gator stalking on Lake Jesup (led by Capt. Soileau in his cruising craft)
- See the pictures via links from http://www.optics.ucf.edu/Partnerships/Affiliates/AffiliatesDay2007/Default.aspx

For additional information on the Industrial Affiliates Program at CREOL & FPCE, The College of Optics and Photonics, visit the Affiliates web site.

Affiliate Vendor: Aerotech, INC

Research Focus: Michael Bass and Martin Richardson


Bass


Richardson

Lasing in a Gain-Guided, Index Anti-Guided Fiber

New approach may provide path to efficient, singlemode, multi-kilowatt fiber lasers.

When you think of an optical fiber, you automatically assume that the core has an index of refraction that is greater than that of the cladding. Light traveling in the core is totally internally reflected from the core-cladding interface, and can travel for great distances with minimal loss. Such fibers are the basic transmission mechanism of our modern telecommunications systems. In the last decade and a half, fiber lasers with very high, multimode output powers have been developed by doping the core of such fibers with ions that can lase. These fiber lasers are pumped by diode-laser arrays coupled into both the core and the cladding to excite ions over the fiber's entire length.

An inherent problem with these powerful lasers is that they cannot readily be made to oscillate in a single transverse mode, so the beam quality is not suitable for some applications. Single mode oscillation requires a small core, typically eight to 10 µm in diameter. Larger cores allow high-order modes to oscillate. But the small core leads to high intensities, and high intensities propagating over long distances lead to deleterious nonlinear effects such as stimulated Raman and Brillouin scattering. Many researchers have proposed clever ways of avoiding the nonlinearities, but none of these to date has provided the robustness and reliability suitable for all applications.

An alternative type of fiber laser has been demonstrated in our lab at CREOL. This laser oscillates only on the lowest-order transverse mode, and because the core can be large, the optical intensity in the core will be limited, so the laser can be scaled to very high powers. Unlike conventional optical fibers, this fiber does not rely on total internal reflection to confine light to the core. Indeed, the refractive index of the cladding is greater than that of the core, so that the fiber is index anti-guiding (IAG). Light generated in the core of the fiber can leak out into the cladding of an IAG fiber, though it experiences some guiding by grazing incidence Fresnel reflection at the core-cladding interface. However, there is loss at each reflection, so an IAG fiber cannot sustain propagating modes the same way a traditional index-guided fiber does.

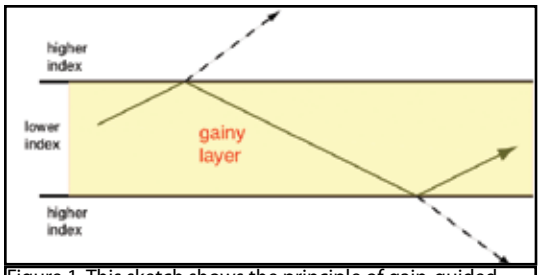

Figure 1. This sketch shows the principle of gain-guided propagation in an index anti-guided fiber. The angles are exaggerated for clarity. If the gain per bounce in the gainy layer equals the loss per bounce, then the light experiences no net loss in propagating in the gain guided index anti guided fiber.

Now consider what happens when we dope the core of an IAG fiber with lasing ions and optically pump it. If we pump hard enough, we reach a point where the gain between core-cladding reflections is equal to the loss at each reflection. At this point, we've reached the threshold for what is called, "gain guiding", where propagation through a length of fiber takes place with no net loss. This threshold is different from the threshold for laser oscillation, the laser threshold: this occurs when the total gain during a round trip of the laser resonator becomes equal to the round-trip loss.

Figure 1 shows the concept of gain guiding. The gain in the "gainy layer" between core-cladding reflections is greater than the loss at the reflection, so a propagating mode is possible without index guiding. In 2003, Anthony Siegman proposed such gain guiding in fibers with negative differences between the index of refraction of the core and the cladding of a fiber [1]. He also showed that the threshold for gain-guiding is mode-dependent, and that low-order modes reach the gain-guiding threshold first [1]. In subsequent work he found that for large negative index of refraction differences the threshold required to guide the lowest-order LP01 mode is 39 percent of that required to guide the next-higher LP11 mode, and that ratio is independent of core dimension [2].

That is a crucial consideration, and it's the reason why gain-guided

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RESEARCH FOCUS from page 5

lasers oscillate only in the lowest-order transverse mode. Once the threshold for gain-guiding has been achieved, more gain is required to overcome other resonator losses (e.g., output coupling) to reach the threshold for lasing. But when this threshold is attained, the gain saturates at the threshold value and never goes any higher. Assuming that lasing threshold occurs at a lower gain than threshold for the next higher mode after the LP01, the LP11 mode, and the modes higher than this never reach threshold. Thus, the laser oscillates only in the lowest order mode, independent of pump power or core size.

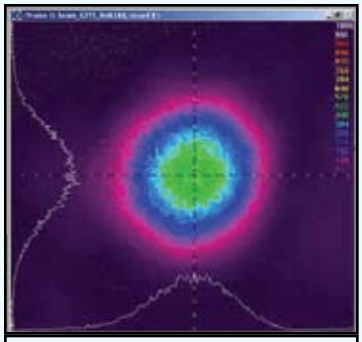

Figure 2. This Spiricon beam-profiler image shows the output beam 152 mm from the output end fiber when pumped at about three times threshold.

In the laboratory, we performed initial experiments to demonstrate this form of gain-guiding, using a fiber with a 100 µm diameter core and flashlamp pumping [3]. While flashlamp pumping does not allow evaluation of the potential efficiency of such fiber lasers, we were able to demonstrate several very important properties of this laser, including spectral narrowing, relaxation oscillations, and lowest-order mode oscillation at pump inputs well above lasing threshold (See Fig. 2). We believe that compact, very-high-power, singlemode fiber lasers may be possible based on gain-guiding. As we'll explain below, pumping geometry and thermal management will be critical issues.

It is conceivable that the observations above could result from an unguided, free-space mode between the back mirror and the front facet of the fiber. However, it is well known that the diffraction losses for free space modes in a resonator increase dramatically as the resonator's Fresnel number, N_f, decreases below one. Since the fiber core diameter was 100 µm, and it was 13 cm long, its Fresnel number was 0.018 when lasing at 1052 nm. Losses for the lowest order free space mode in this fiber were very, very large (>10 dB per transit), whereas the round-trip gain of our resonator was only 5 dB. The losses for higher-order modes are even higher. Therefore there is no possibility of free-space mode oscillation in the current laser setup.

Subsequently, we demonstrated single mode oscillation in 200-µm-diameter core gain-guided, index anti-guided fibers, by paying careful attention to the interplay between the gain-guiding thresholds of the two lowest order modes and that required for laser threshold [4]. These results were obtained at inputs up to 10 times threshold, showing that single mode operation is very robust against breaking into multimode outputs.

We recently applied the concepts developed in the flashlamp pumped laser experiments to a diode-pumped, end-pumped laser, and again obtained robust single mode operation. End pumping an index anti-guided fiber is not as simple as it sounds at first. Since pump light can be trapped in the cladding it may not get into the core and this can lead to significant inefficiency and limited scalability. Side pumping with diode pump sources that are properly tailored to the absorption features of the gain medium can be efficient, and scales with the length of the fiber. As a result, we are exploring this possibility as an approach to high-average-power, single mode fiber lasers. As with any laser, issues of thermal management and the removal of waste heat are critical to further development.

With sufficient doping levels, fiber lengths from a few centimeters to several meters may be all that is necessary for laser operation with either end or side pumping. The latter becomes feasible with a heavily-doped, large-diameter core so that pump light is efficiently absorbed. The properties of gain-guided, index anti-guided fiber lasers may offer a path to efficient, single mode, multi-kilowatt fiber lasers.

ACKNOWLEDGEMENTS

This work was sponsored by DoD JTO MRI contract W911NF-05-1-0517.

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Dr. Michael Bass
Emeritus Professor of Optics, Physics & ECE

Dr. Martin C. Richardson
Northrup Grumman Professor of X-ray Photonics

Awards and Honors:

FACULTY NEWS

MJ Soileau has received OSA's Esther Hoffman Beller Award for "distinguished and long-standing service to the optics education and research community.

Shin-Tson Wu was elected to be a fellow of the SPIE "for specific achievements in liquid crystal optics and electro-optics".

Pieter Kik has received an NSF Career ward for "CAREER: Silicon Compatible Hybrid Nanophotonic Systems" which will cover two graduate students for a period of five years

STUDENT NEWS

Frank Quinlan's (student of Peter Delfyett) paper entitled "Optical frequency self stabilization in a coupled optoelectronic oscillator" won the student poster competition at the joint conference of the European Frequency and Time Forum (EFTF) and IEEE Frequency Control Symposium (FCS), May 29 through June 1, 2007 in Geneva, Switzerland.

Florian Fournier, a student working in Jannick Rolland, was selected for the 2007 International Michael Kidger Memorial Scholarship. The Michael Kidger Memorial Scholarship was established in 1998 to honor Michael John Kidger. The 2007 award is a study grant of $5,000.

SPIE Educational Scholarship in Optical Science and Engineering in the amount of $1,000

Mr. Gilard Goldfarb	$1,000
Ms. Ying Zhou	$3,000
Mr. Zhibing Ge	$3,000
Mr. Xiangyi Nie	$1,000
Ms. Amy Thompson	$1,000

Jose Cunado, a graduate student working for Martin Richardson, won the 2007 Graduate Research Forum Award for the best presentation in Engineering at the 4th Annual Graduate Research Forum of the University of Central Florida.

Graduate student **Jung-Hyun Cho** working with Michael Bass, was chosen as a Distinguished Contributed Paper for the 2007 SID International Symposium. Co-authors: Jung-Hyun Cho, Hans P. Jenssen and Michael Bass.

Ms. Ying Zhou was one of the 7 finalists of the prestigious OSA New Focus/Bookham Award. We are proud that she is keeping the tradition alive.

Amy Thompson, a graduate student working for Winston Schoenfeld, won a 2007 National Defense Science and Engineering Graduate (NDSEG) Fellowship which comes with a $30k Fellowship for three years.

Ozan Cakmakci, a graduate student working with Dr. Rolland, won 1st place in the 2nd Annual Fashion in Motion College Scholarship Program For Technology & Fashion Students for the Eyeglass Display. This comes with a $10K Scholarship

Panomsak Meemon was selected as a UCF I2Lab Fellow 2007 for his interdisciplinary research PhD proposal in biophotonics under the mentorship of Jannick Rolland (CREOL) and Hassan Foroosh (Comp. Science). This comes with a $25K Fellowship for one year.

Dr. Arthur H. Guenther

It is with great sadness and profound loss that we mark the passing of our friend and colleague, Dr. Arthur H. Guenther, aka, Doc Guenther, or just Art. Art passed away, with his family at his side on Saturday, April 21, 2007, the day after his 76th birthday.

-M.J. Soileau and the CREOL Family

Spring 2007 Graduates

Andrew Greenwell
Optics Ph.D.
Advisor: M.G. Moharam

Weiyao Zou
Optics Ph.D.
Advisor: Jannick Rolland

Yat Ming Tony Ho
Optics M.S. Non Thesis

Georgios Siviloglou
Optics M.S. Non Thesis

Sergiy Suntsov
Optics M.S. Non Thesis

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