Charles Townes: Creator of the Discipline of Photonics

Robert W. Boyd

(Part of the) Charles Townes Legacy

Inventor of the Laser
Discoverer of Fundamental Nonlinear Optical Processes
   Autler-Townes Effect
   Self Trapping of Light (Optical Solitons)
   Stimulated Brillouin Scattering (SBS)
Also, his research group discovered light-by-light scattering
   (the essence of photonics)

Presented at The Charles H. Townes Centennial Celebration Symposium, University of California at Berkeley, August 1 and 2, 2015.
What is Photonics?

And how is it different from optics?

Answer 1:
     Optics is old name
     Photonics is new name

Answer 2:
     “Optics” has always been a misnomer.
     Optos is Greek for vision.
     Photos is Greek for light.

Answer 3:
     Photonics is doing useful things with light.
     (As in the distinction between electronics and electricity.)
The elementary process of light-by-light scattering has never been observed in vacuum, but is readily observed using the nonlinear response of material systems.

Joe Biden announces that Rochester will host the Institute for Manufacturing Innovation in Integrated Photonics (a part of the National Photonics Institute), July 27, 2015.

Funding for five years to exceed $600 Million.

Photonics has a huge commercial impact: a $150 billion yearly market, world wide.
THE SCHAWLOW-TOWNES SYMPOSIUM ON PHOTONICS

THE SCHAWLOW-TOWNES SYMPOSIUM ON PHOTONICS IS NAMED IN HONOUR OF CHARLES H. TOWNES AND THE LATE ARTHUR L. SCHAWLOW, PIONEERS IN LASER TECHNOLOGY.

For this inaugural event, the University of Ottawa is delighted to present the following internationally acclaimed keynote speakers:

Friday, November 9, 2012
1 p.m. to 4 p.m.
Ottawa Convention Centre, Room 204
55 Colonel By Drive, Ottawa, Ontario

Also on that day: 9:30 a.m. to 12 p.m.
Presentations by
Olga Smirnova (Max Born Institute, Berlin)
Albert Stolow (National Research Council of Canada)
Ksenia Dolgaleva (University of Toronto)
Jeff Lundeen (National Research Council of Canada)

Seating is limited.
Register online (free).
For more information:
judith.lachance@uottawa.ca

Erich Ippen
World-renowned expert in femtosecond optics, Massachusetts Institute of Technology

Gerd Leuchs
Director, Max Planck Institute for the Science of Light, Germany

Charles H. Townes
Nobel laureate in physics for his groundbreaking work in quantum electronics
One of My Contributions to the Field of Photonics

Some of My Research Projects

(But only the fun projects!)
Controlling the Velocity of Light

“Slow,” “Fast” and “Backwards” Light

– Light can be made to go:
  slow: \( v_g \ll c \) (as much as \( 10^6 \) times slower!)
  fast: \( v_g > c \)
  backwards: \( v_g \) negative

Here \( v_g \) is the group velocity: \( v_g = c/n_g \)
\( n_g = n + \omega (dn/d\omega) \)

– Velocity controlled by structural or material resonances

How to Control the Group Velocity of Light

\[
\alpha = n + \omega \frac{dn}{d\omega}
\]

\[
g = n + \omega \frac{dn}{d\omega}
\]
Observation of Superluminal and “Backwards” Pulse Propagation

- A strongly counterintuitive phenomenon

- But entirely consistent with established physics


- Observed by Gehring, Schweinsberg, Barsi, Kostinski, and Boyd Science 312, 985 2006.

- Conceptual prediction

- Laboratory results

Normalized length $|n_g|Z$ (m)

Propagation distance
Observation of Rotary Photon Drag

The world as seen through a spinning window.
(Laser-excited ruby has a group index of $10^6$.)

Experimental setup

rotating, 10-cm-long ruby rod

Effect clearly visible by eye!

Franke-Arnold, Gibson, Boyd and Padget, Science, 2011
Observation of Optical Polarization Möbius Strips

Möbius strips are familiar geometrical structures, but their occurrence in nature is extremely rare. We generate such structures in the nanoscale in tightly focused vector light beams and confirm experimentally their Möbius topology. This work demonstrates that focused optical fields can possess complex structure at sub-wavelength distances and that advances in nano-optics provide the tools to probe these features.

Bauer, Banzer, Karimi, Orlov, Rubano, Marrucci, Santamato, Boyd and Leuchs, Science 347, 964 (2015)
Townes and Portraits

Charles H. Townes