spent a significant part of our time showing visitors what we were doing, and every alkali distillation and glass-to-metal seal was scrutinized by all the experts. We knew of Ali Javan's work at Bell Telephone Laboratories from the preprint he sent us on He–Ne transfer as a new pumping mechanism. Most of the other industry groups were essentially working under wraps.

In the spring of 1959 a significant event took place at CRL that had an impact on the optical maser program. Townes announced at a rare meeting of all his graduate students and postdocs that he intended to leave Columbia in the summer to become vice president of the Institute for Defense Analysis in Washington; students could change thesis adviser if they so chose. I was the last student Townes had brought in at Columbia, and was considerably agitated by the news. Townes reassured Cummins and me that he was very interested in the maser problem, would come back to New York on weekends to supervise and would bring in some senior staff to help out. So it was that Oliver Heavens from the UK, a noted expert on evaporated thin films, joined the Columbia group as a visiting research professor. Also joining the group, a year later, was Norman Knable, who subsequently worked with Cummins and Yin Yeh on modulated laser scattering from acoustic modes in liquids.

Following the September 1959 Shawanga conference, we turned to cesium as the active medium. Cesium could be pumped by an accidental coincidence of the He 3888-Å line and the Cs 6s–8p transition.[2] There was too much quenching in potassium vapor, probably due to trace amounts of hydrogen. I made one last attempt in potassium at Bell Labs when Schawlow volunteered the use of his new Jarrell–Ash spectrograph (painted with the royal blue and white colors of the University of Toronto). I used a high-pressure mercury arc pump, whose pressure-broadened line at 4046 Å overlapped the K line clearly in absorption. But no fluorescence was observed.

The cesium–helium system with an elliptical cylinder formed the basis of our work until June 1960. Fluorescence measurements and other tests gave promising results and suggested that modest improvements might produce success. Heavens had purchased a complete Edwards high-vacuum evaporating plant, and under his direction we made antireflecting films for the sapphire windows on the cesium cells. Brewster windows had not yet appeared on the scene. In 1960 Schawlow joined the group for the spring semester as a visiting professor and helped us set up a new 3-meter Jarrell–Ash spectrograph that had just been delivered to CRL.

The cryptic remark in PHYSICS TODAY that the management at Hughes Laboratories was "fearful that Columbia University would scoop Hughes" in June 1960 needs some amplification. The first Rochester Conference on Coherence, organized by Emil Wolf, took place in the middle of June, with Cummins and Heavens in attendance. Heavens gave an optimistic account of our progress at Columbia, probably giving the impression that we were on the verge of announcing a positive result. In fact, we were not any closer to laser threshold at that point than we had been for several months. (In spite of continued efforts in 1960–61, the cesium laser never operated at Columbia; but Paul Rabinowitz, Gould and Stephen Jacobs at TRG succeeded with this some time later.) Malcolm Stitch, then at Hughes, telephoned back to management with the "news" of the imminent Columbia result, which probably helped force a public disclosure of the Maiman work at that time.

Following the Maiman–Hughes announcement at the end of June, Townes asked me to duplicate this result using an oriented ruby boule that William Rose had obtained for maser radiotelescope work. Our flash-lamp-pumped ruby laser operated in August 1960, and it was with this device that we demonstrated polarized laser emission and the first tunable laser.[3]

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# Metastable and Stable Negative Ions

In the Search & Discovery story (June 1988, page 22) announcing the unanticipated and quite exciting discovery of stable negative calcium ions,[1] we are cited as having predicted the existence of a metastable negative calcium ion, but there is no mention of what we were looking for.

Our motivation[2] was to search for core-excited metastable negative ions, not for stable negative ions, and our reason for doing that was to look into another interesting phenomenon, which possibly occurs only in negative ions, namely the existence of two-level systems—that is, systems in which two atomic energy levels are connected only with each other and through electric-dipole radiation. Two-level systems were first found in core-excited negative lithium.[3] In our 1982 paper[2] we predicted the existence of a two-level system in core-excited negative calcium and of five new two-electron systems that should emit narrow-line radiation (namely Be, Mg, P, S and Ca core-excited negative ions).

Other than a molecular two-level system, also discovered in 1980,[4] no new two-level systems have been experimentally detected since then, although metastable negative argon has been observed,[5] as predicted,[2] while metastable negative neon could not be detected,[5] also as predicted.[2] It is perhaps high time to refocus interest in two-level systems, for which much unverified basic theory has been available for some time.

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*8/88*

# Correction

**March, page 89**—In the table, the average annual increase in French funding for the life sciences from 1978 to 1988 should have been 11.6%. ■