A history of hole burning

Richard Brewer, Aram Mooradian, and Boris Stoicheff, in their review "The Early Days of Precision Laser Spectroscopy" (Physics Today, January 2007, page 49), implied that Willis Lamb conceived of the notion that his dip at line center could be explained through hole-burning effects. In fact, Lamb had no physical interpretation of the tuning dip when he first showed by purely mathematical analysis that the dip might exist. After reading his original manuscript, I suggested hole burning to him in a letter dated 7 July 1962 (available at the online version of this letter).

The subject had come up in a lecture I gave, attended by Gordon Gould, on my previous research on hole-burning effects.[1] I had only discussed the effects of running waves in one direction, and Gordon asked, "What about the other running wave in the standing wave?" After drawing a diagram on the blackboard, I realized, as did Gordon, that the presence of the second running wave would result in a dip as the laser was tuned through line center.

These holes in the Doppler line approach each other and overlap at the middle. Because the power stimulated in each hole falls within about a natural width of the atoms' Doppler-shifted frequency, the number of atoms stimulated to emit at line center can decrease by a factor of two. After showing that interpretation to Lamb, I published it later that year in a review paper on gaseous optical masers.[2]

During my time at Bell Laboratories, Ross McFarlane and I started an experiment to look for the dip in a helium–neon laser using a much shorter length than the one I had described in reference 1. I was in the process of moving from Bell Labs to Yale University, and McFarlane had to finish the experiment alone. He was the first to observe the tuning dip experimentally, but for several months we withheld publication of a paper reporting the results[3] until Abraham Szoke and Ali Javan had had a chance to verify the effect at MIT.

While waiting for their experiment, I showed that the "mirror-image" hole in the Doppler profile was responsible for the "mode-pushing" effect described in Lamb's theory and that the hole-burning interpretation led to the same single-mode equations as his third-order theory (with different notation). I presented those results at the Paris Quantum Electronics Conference in February 1963, but the volume containing my paper describing those equations, wasn't published until a year later.[4] That work was discussed in much more detail in an article based on lectures that I gave at Brandeis University in the summer of 1969.

One final aspect of the role of hole-burning effects in laser spectroscopy that was omitted in the otherwise fine article by Brewer and coauthors is the narrow absorption peaks initially observed in 1968 by Veniamin Chebotayev and his student V. N. Lisitzin at Novosibirsk, Russia, in a laser containing a saturable absorber.[5] The extremely narrow resonant peaks they found were due to hole-burning effects in the Doppler-broadened absorber. Chebotayev and Lisitzin also extended that work to include tuning dips from strong-wave–weak-wave interactions in external absorption cells, a process that anticipated the later, more elegant work by Theodor Hänsch, Marc Levenson, and Arthur Schawlow.[6] In those experiments, the strong wave burns a hole in the line that is probed by a weak wave traveling in the opposite direction. Since the absorber can involve a ground-state atom or molecule, much narrower natural widths can be obtained in the absorber experiments than in those with the amplifying medium.

References

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What? No code?

In the review of the book *Introduction to Computational Science* by Angela B. Shiflet and George W. Shiflet (Physics Today, April 2007, page 62), I found a line that caused me concern. Since I haven't read the book, I am not in a position to comment on its merits, but the reviewer, Wouter van Joolingen, strongly endorses it. My concern is with the reviewer's statement, "Let me reassure those who fear that computational science is not for them because they are not programmers: The book does not contain a single line of programming code."

Am I the only person who has noticed that while computers have become ubiquitous, the number of people who can actually program appears to be falling? No doubt many problems in the physical sciences can be solved using commercially developed, freely available black boxes, but how can students learn to choose the most appropriate black box if they are not encouraged to code for themselves some of the simpler and more common numerical methods? What happens if no black box is available to solve a particular problem? It is clearly not necessary for all users of computational techniques to be able to program, but the trend away from teaching science students how to program is worrying.

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