

Teich M C. Infrared heterodyne detection. *Proc. IEEE* 56:37-46, 1968.
[MIT Lincoln Laboratory, Lexington, MA]

Heterodyne experiments have been performed in the middle infrared using the CO₂ laser in conjunction with photoconductive Ge:Cu and photovoltaic Pb_{1-x}Sn_xSe detectors. The observed minimum detectable power is a factor of five to 25 greater than that for the theoretically perfect quantum counter. The technique should prove useful for infrared communications, radar, and heterodyne spectroscopy. [The SC[®] indicates that this paper has been cited over 75 times since 1968.]

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July 20, 1981

"My interest in the detection of electromagnetic radiation stretches back to the early 1950s. Thanks to my dad, who was a shipboard radio operator and avid radio amateur, I developed quite an interest in electronics and communications at an early age, and managed to get my FCC license (W2KGA, which I still hold) when I was 12. The research that I carried out as a student was colored by these early experiences. My PhD thesis at Cornell was concerned with the photodetection of pairs of quanta. As a graduate student in 1963, I was pondering the best way to observe the two-quantum photoelectric effect in sodium metal and it occurred to me that the then newly developed GaAs injection laser was a light source that had just the right properties to elicit the effect. My advisor, George Wolga, immediately contacted some friends at MIT Lincoln Lab and there I was, on a visit a week later, receiving a gift of two shiny new lasers and a stern lecture from Ted Quist on how to avoid burning them out. The lasers worked beautifully and enabled me to complete my experiments and demonstrate the effect.¹

"My visit to Lincoln Lab, and the people that I met there, left me impressed and a bit awed, so it was quite natural that I should go there after completing my studies. I was lucky to join a group headed by Bob Kingston and Bob Keyes. Many

new infrared detectors were being developed at the Lab, and Kingston and Keyes suggested examining some of these in the heterodyne configuration. Ivars Melngailis offered to provide us with some of his new lead-tin chalcogenide photovoltaic devices. I questioned the merit of conducting the experiments at all, since I knew from my student days at Stanford in 1962 that Tony Siegman's optical heterodyne experiments were successful. It seemed clear to me from the theory that infrared heterodyne detection had to work, but Keyes and Kingston convinced me that it was indeed worth demonstrating experimentally. After quickly establishing the configuration, we set up the experiments, and work they did We published the first demonstration of the effect in 1966,² and this led to the more extensive study in *Proceedings of the IEEE*.

"I was delighted with the experimental results, but did not realize how much interest the work generated until 1969 when the IEEE awarded me the Browder J. Thompson Memorial Prize Award (for the best paper by an author under 30 years of age in any IEEE publication). Some years later, the paper received further attention; it was reprinted in *Benchmark Papers in Optics*.³ I subsequently extended the work in a number of directions, as described in a review article published in 1970.⁴ A second review article, detailing the theoretical behavior of more esoteric nonlinear heterodyne systems, appeared in 1977.⁵

"It is a nice coincidence that heterodyne detection had some of its earliest beginnings at Columbia University, as I described in a recent article⁶ In 1921, Edwin Armstrong of the department of electrical engineering developed the superheterodyne receiver, and this famous invention is now used in systems as diverse as household AM radio receivers and microwave Doppler radars. This may be one reason that this paper is highly cited. Heterodyne detection has proved so useful at lower frequencies that its extension to the middle infrared, with the availability of the high-power CO₂ laser source and atmospheric window, was eagerly sought. The paper provided an experimental demonstration, and a theoretical description, that was early enough to be simple and therefore widely appreciated."

1. **Teich M C, Schroeder J M & Wolga G J.** Double-quantum photoelectric emission from sodium metal. *Phys. Rev. Lett.* 13:611-14, 1964.
2. **Teich M C, Keyes R J & Kingston R H.** Optimum heterodyne detection at 10.6 μm in photoconductive Ge:Cu. *Appl. Phys. Lett.* 9:357-60, 1966.
3. **Teich M C.** Infrared heterodyne detection. (Hudson R D, Jr. & Hudson J W, eds.) *Benchmark papers in optics. Vol. 2. Infrared detectors.* Stroudsburg, PA: Dowden, Hutchinson, and Ross, 1975. p. 87-96.
4. Coherent detection in the infrared. (Willardson R K & Beer A C, eds.) *Semiconductors and semimetals. Vol. 5. Infrared detectors.* New York: Academic Press, 1970. p. 361-407.
5. Nonlinear heterodyne detection. (Keyes R J, ed.) *Topics in applied physics. Vol. 19. Optical and infrared detectors.* New York: Springer-Verlag, 1977. p. 229-300.
6. The physics of heterodyne detection in the far infrared: transition from electric-field to photon-absorption detection in a simple system. (Katzburg S & Hoell J M, eds.) *Proceedings of the international conference on heterodyne systems and technology, March 1980. Williamsburg, VA.* NASA conf. publ. no. 2138. Washington, DC: NASA, 1980. p. 1-10.