Lasers in the Physics Department Simon Fraser University 1969-1971

The concept of laser beams has a history that can be traced back to (at least) “The War of the Worlds” by H.G. Wells, first published in 1898. The actual devices were invented in 1960. The first operating laser was a Ruby built by Theodore (Ted) Maiman at Hughes Aircraft Company in Malibu California. Ted Maiman later was an Adjunct Professor at Simon Fraser University, studying biological effects of lasers; he received an honourary degree from SFU.

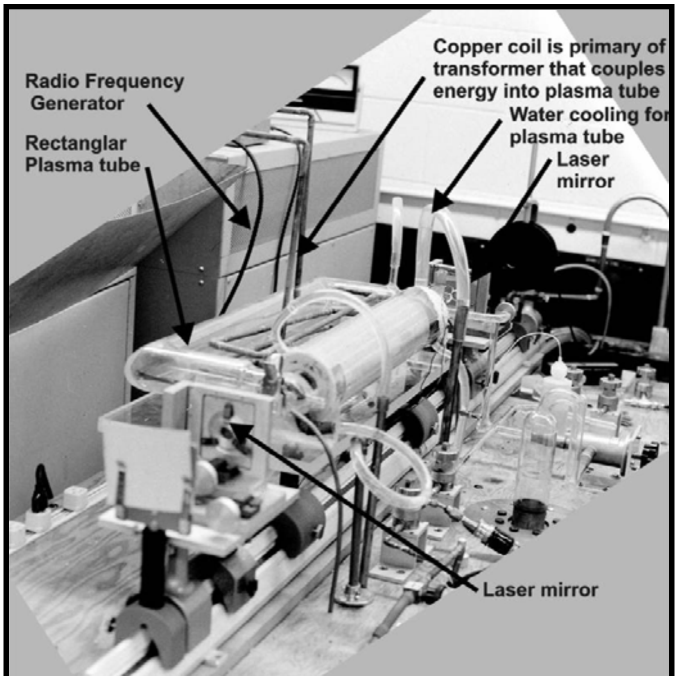

Figure 1 The Argon Ion Laser in the SFU Physics Department 1970

I was a “charter” student at Simon Fraser University. When I graduated with a Bachelor of Science degree in 1969, my parents bought me a camera as a graduation present. I subsequently became a graduate student in the SFU Physics Department from 1969 to 1971 and used my camera to take pictures of the various lasers in the department. These included an Argon Ion Laser, a Transversely Excited Carbon Dioxide Laser, a Hydrogen Cyanide Laser, and Neodymium Glass lasers. This is about ten years after lasers were first built, which is now 54 years ago.

The **Argon Ion Laser** was in the laboratory of J.C. “Chuck” Irwin, Professor of Physics. There were no commercially available Argon Ion lasers at the time, so this one was “home made”. The power from a radio transmitter was directed into a large coil which formed the primary of a transformer. The power was transferred to the secondary of the transformer which in this case was a plasma tube which surrounded the coil, as shown in figure 1. The air from the plasma tube had been evacuated and replaced by a low pressure of argon gas. The radio frequency (RF) caused the gas to ionize, and the ionized gas carried a electrical current. In one branch of the rectangular plasma tube, a solenoid produced a magnetic field which compressed the electrical current increasing its density and the intensity of the light that was created by the interaction of the current with the argon gas atoms. Two mirrors at each end of this segment of the plasma tube extracted some of the energy emitted by the argon ions in the form of laser radiation. One of the mirrors could be replaced by a prism- rotating the prism allowed selection of the wavelength of light at which lasing occurred. The most common wavelengths were 488 and 514 nanometers – blue and green light. The laser radiation was used to induce Raman scattering in solids. This is a process in which the incident light interacts with the vibrations of the crystal structure of the solid, casing the creation of new light beams that are different from the wavelength of the incident light be a factor related to the frequency of vibration of the crystals atoms. Studying this frequency difference allowed the determination of the crystal structure.

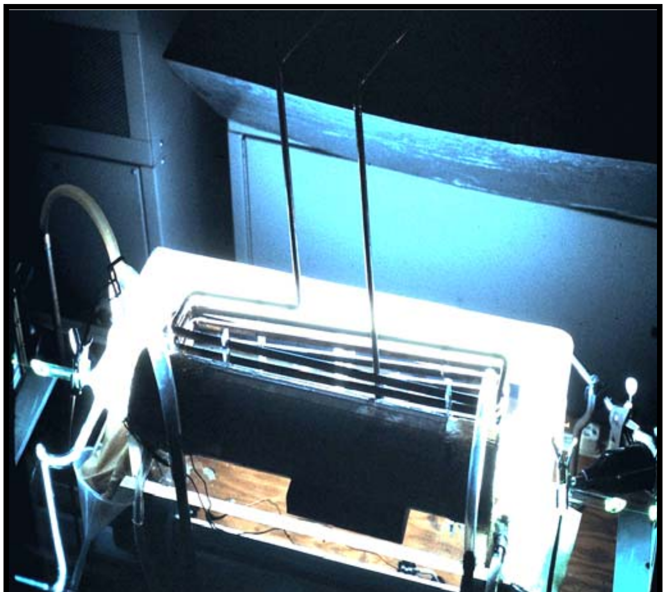
Figure 2 The Argon Ion Laser with RF energy applied to ionize the gas and produce laser output

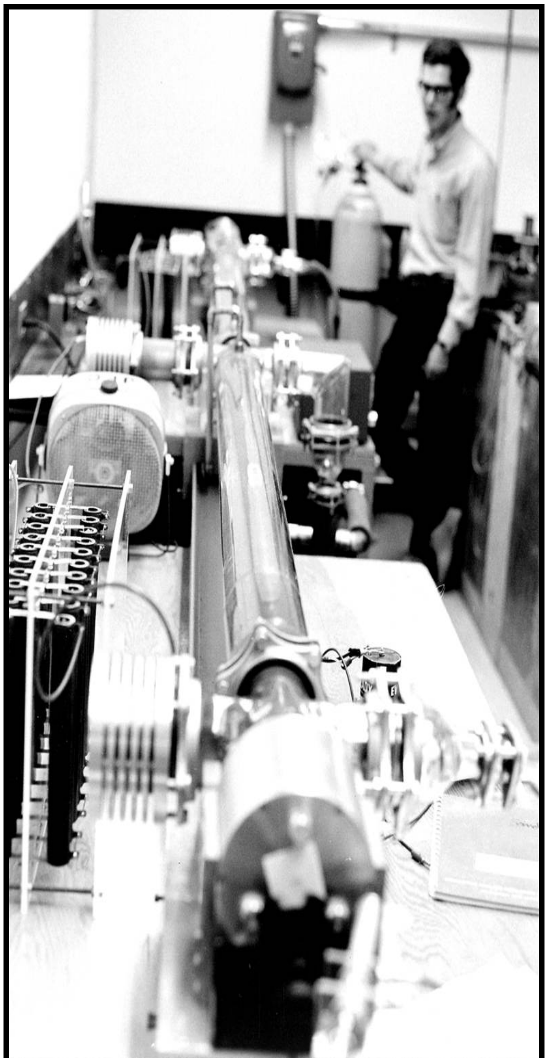

Figure 3 The HCN Laser with research technician Brian Farnworth. Mr Farnworth later earned his Ph.D. from McMaster.

Jim Lacombe used this laser for his Ph.D. (Doctor of Philosophy) research under Chuck Irwin's supervision. His thesis, awarded in 1971, was titled "Raman Scattering of Photon Dispersion in Zinc Blende Semiconductors". Jim subsequently went on to teach at Cariboo College (which became Thompson Rivers University), then at Royal Roads.

The Hydrogen Cyanide (HCN) Laser was a research tool that was built at SFU in the 1970-1971 time period under the supervision of Professors Chuck Irwin and Bruce Clayman. It was a large laser, and was built in an in-frequently used maintenance corridor at the edge of the Science Complex. The main structural components of the laser were inexpensive glass sewer pipes. A T-joint in the sewer line allowed connection of the main tube to a vacuum pump which evacuated the air from the chamber which was subsequently filled with a mixture of gases such as Argon, Nitrogen, and methane. Electrodes machined in the SFU science machine shop were installed in T-joints for the sewer lines, and connected to the main discharge chamber. A high voltage power supply was connected to the electrodes, and the current flowing through the low pressure gas in the main discharge chamber caused the decomposition of the molecules in the gas mix. Recombination of the dissociation products resulted in the formation of the molecule HCN in excited states which radiated energy in the form of laser radiation.

The laser radiation was in the far infrared portion of the electromagnetic spectrum, at 454000 nanometers wavelength (electromagnetic radiation that our eyes detect as "light" is between 400 and 700 nanometers in wavelength). The far infrared radiation was useful for investigating the properties of solid matter. The laser was extremely inefficient in terms of the ratio of electrical energy drawn from the grid to laser energy output, but radiation sources in the far infrared are so scarce that the inefficiency was justified.

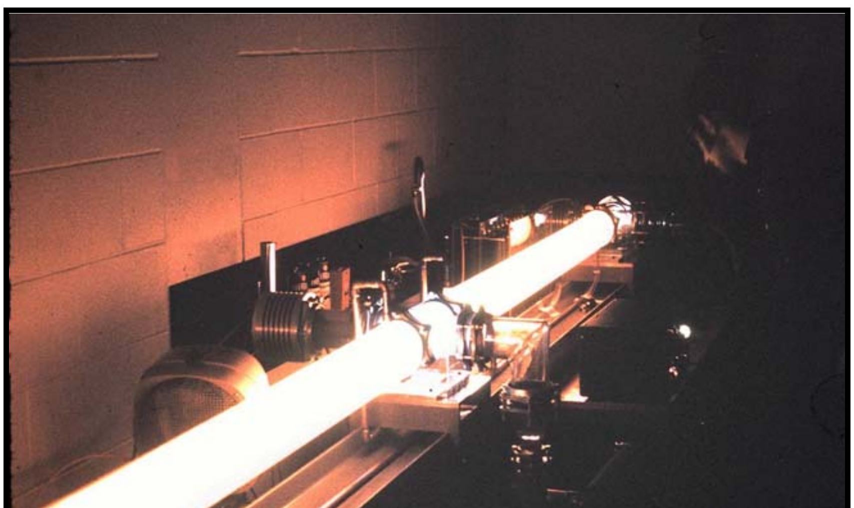

Figure 4 The HCN laser was very impressive when the electical discharge was activated.

The term "cyanide" is very familiar to readers of Agatha Christie's detective novels as a choice method of murder. But the low pressure of the gasses used in the laser meant that there was no significant accumulation of the product of the reactions produced by the electrical current. Those working in the nearby laboratories were warned that cyanide had an odour like that of burnt almonds, but this was never observed.

The **Transversely Excited Carbon Dioxide laser** at SFU was the writer's Masters of Science thesis project, under the supervision of Chuck Irwin. The carbon dioxide laser

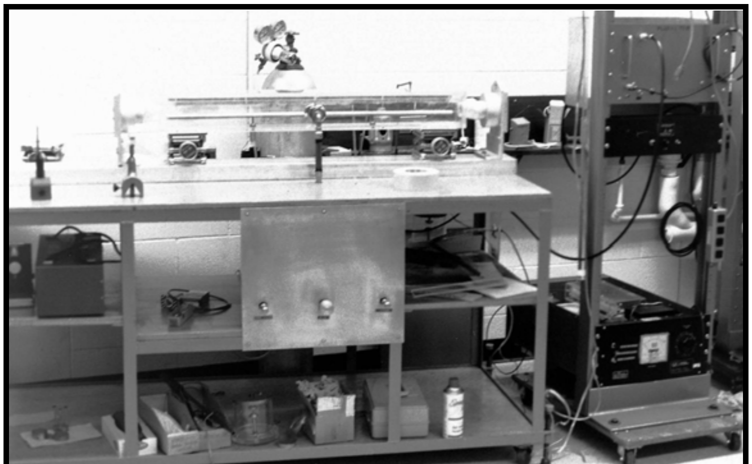

Figure 5 The TEA Laser is the Plexiglass box on the table. Power supplies and trigger circuits are in the vertical rack.

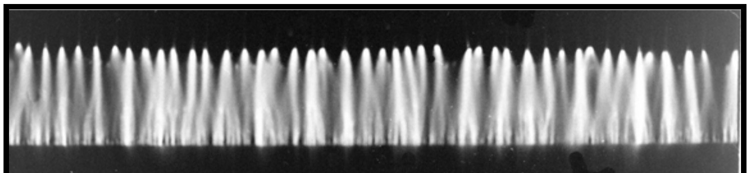

Figure 6 Pulsed Electrical Discharge in the TEA Laser

had been invented in 1966, but "conventional" carbon dioxide lasers required vacuum pumps to create a low pressure gas through which electrical current could pass. A new design of carbon dioxide lasers operated at atmospheric pressure so no vacuum pumps were required which simplified the laser configuration. The price paid for this simplification was a dramatic increase in the operating voltage – if the gas pressure increases, voltage requirements increase. The voltage was kept to a reasonable range by having the electrical discharge go transverse to the length of the tube, instead of along the tube as in the more usual laser design. This laser style was invented at the Canadian Defence Research Establishment in Valcartier, but a variation was built at SFU. These lasers were called "TEA" lasers, after "Transversely Excited Atmospheric Pressure".

The problem with an electrical discharge through a high pressure gas is that the current may collapse into a very high current but localized "arc" rather than a uniform glow discharge that excites a large volume of gas. The Valcartier design of lasers used a long series of electrical resistors to limit the flow of current and prevent high current arc discharges. An example of the resultant discharge, in a transverse view, is shown in Figure 6. Although from the side view there is a lack of uniformity in individual discharge channels, in a longitudinal view, along the axis of all the discharge channels, there is a significant volume of electrically excited gas which leads to laser action at an output wavelength of 10600 nanometers in the infrared. The multitude of electrical resistors required to produce the laser output makes the laser construction tedious. This author replaced the multitude of resistors with simple brass bars; this research resulted in a thesis "Operating Characteristics of a TEA laser with Brass Electrodes", presented in April 1971. The laser is the plastic box on the table in Figure 5; because of the absence of vacuum pumps and hermetic seals, the construction is significantly simpler than other lasers shown in this article.

Neodymium Glass Lasers are a variety of the Ruby Lasers first developed by Ted Maiman. The Ruby crystal of Maiman's first laser is replaced by a rod of glass containing Neodymium atoms; in both cases the crystals are excited by the light from pulsed intense lamps. The excited atoms in the Neodymium-doped-glass emit radiation at 10600 nanometers, in the near infrared region of the spectrum. A graduate student, Ron Ninnis, studied the Neodymium glass laser under the supervision of Klaus Reickhoff of the Physics Department, producing an M.Sc. Thesis "Design and Performance Characteristics of a Mode-locked Neodymium-Glass Laser" presented in June 1972. Ron Ninnis went on to get his Ph.D. from the University of British Columbia, and to establish a consulting company "Eclectic Research". Klaus Reickhoff became the Associate Dean of Graduate Studies at SFU, and a long term member of the Board of Governors; Reickhoff Hall is name after him.

A mode-locked laser is one in which the various "modes" that can be amplified by a laser system operate with a defined time sequence so that they can interfere with each other. Each mode is at a slightly different wavelength but in each case the cavity, or distance between the two laser mirrors, is a multiple of the laser wavelength. All the wavelengths can be amplified by the excited atoms or ions in the laser media. The interference leads to very short duration light pulses, about a millionth of a millionth of a second in duration. The building of such a laser at SFU in this time period was a state-of-the-art achievement.

V.E. (Vivian) Merchant
October 2014