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HISTORY OF FREE ELECTRON LASERS (FEL) IN ISRAEL AND ESTABLISHMENT OF THE CENTER FOR COMPACT ACCELERATORS DEVELOPMENT IN ARIEL

(English synopsis)

AVRAHAM GOVER

In memoriam of:

Yigal Cohen Orgad and Prof. Yuval Neeman – Leaders of the FEL project

Haim Kleinman, Jerzy Sokolowski, Arie Eichenbaum, Miki Kanter, Boris Kapilevitch and Dimitri Borodin – The project pioneers

In this monograph I present the history of FEL research and development in Israel with focus on the establishment of the Israeli FEL center a joint project of of Tel Aviv University and Ariel University and the center for compact accelerators development in Ariel.

1. Free Electron Lasers (FEL)

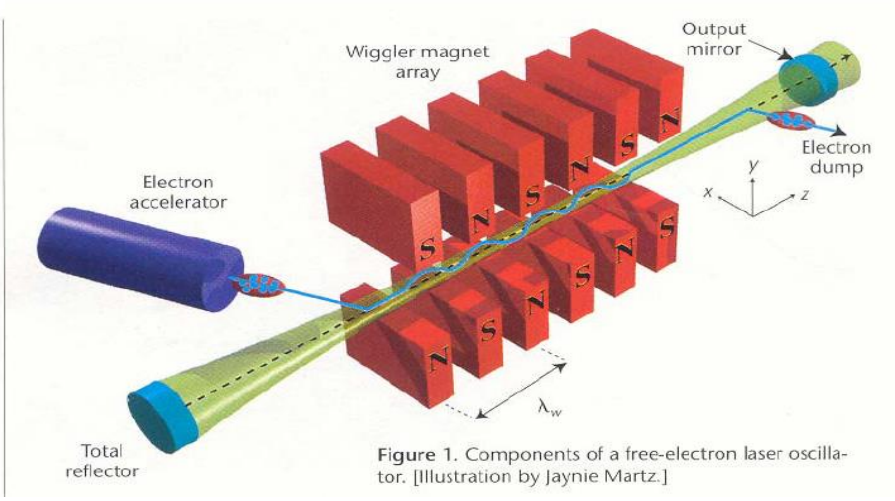

Fig 1: Schematic structure of a free electron laser (FEL). An electron beam is accelerated to high energy in an electron accelerator, injected into a periodic magnetic structure (WIGGLER). Due to the transverse oscillation of the electron charge, electromagnetic radiation (light) is emitted. The radiation frequency is high the higher the electron energy (from microwaves to X-rays). The figure depicts a FEL oscillator (laser oscillator) in which the radiation is trapped and amplified between two mirrors. In most applications, the laser is built in the configuration of an amplifier (FEL amplifier): a light beam is injected together with the electron beam and comes out amplified after the WIGGLER.

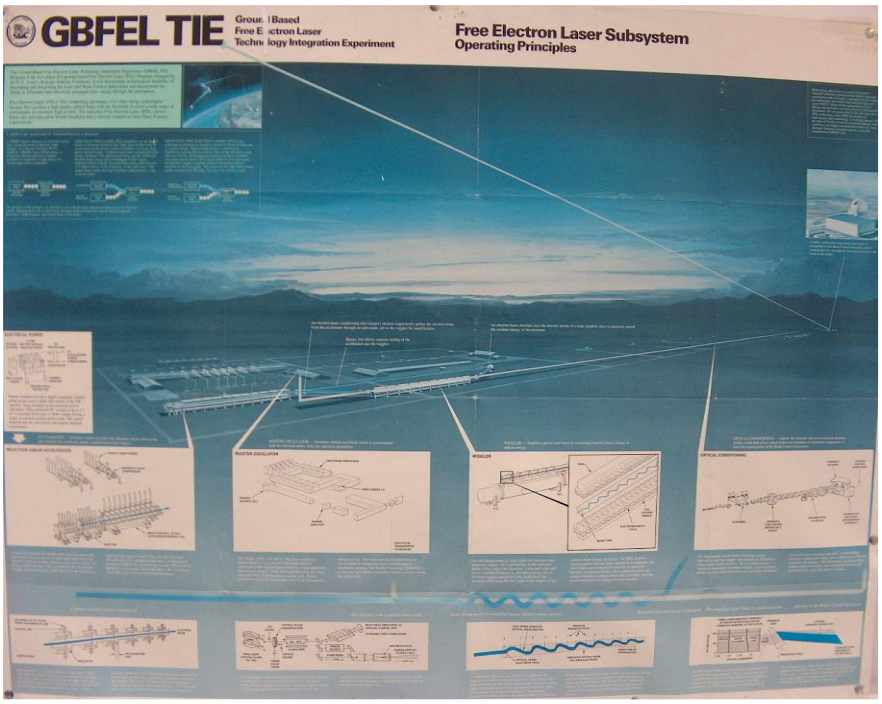

Fig 2: Conceptual illustration of the FEL-based laser weapon system of SDI (Strategic Defense Initiative) based on a ground platform, designed to intercept missiles with a nuclear warhead in flight in outer space before re-entering the atmosphere. The powerful laser beam produced at the output of the FEL is launched to a distance of over a kilometer in order for it to expand and not damage the relay mirror which directs it out of the atmosphere. "Fighting mirrors" in space aim and focus the beam on the target.

Fig 3: : The world's first X-Ray FEL (SLAC-LCLS). Lased for the first time on April 10, 2009 in the wavelength range 1.5-15 Angstrom. The FEL is based on a kilometer-long LINAC accelerator with an acceleration energy of 13.6 Gigavolt and a wiggler (undulator) 112 m long.

2. The early start of FEL research in Israel

3. The Tandem-FEL project in the Weitzman Institute

Free Electron Maser demonstration experiment in TAU

AFOSR, ONR (1977-1984)
Israel MOD (MAFAT/MATAT)

H. Kleinman
A. Eichenbaum
S. Ruschin

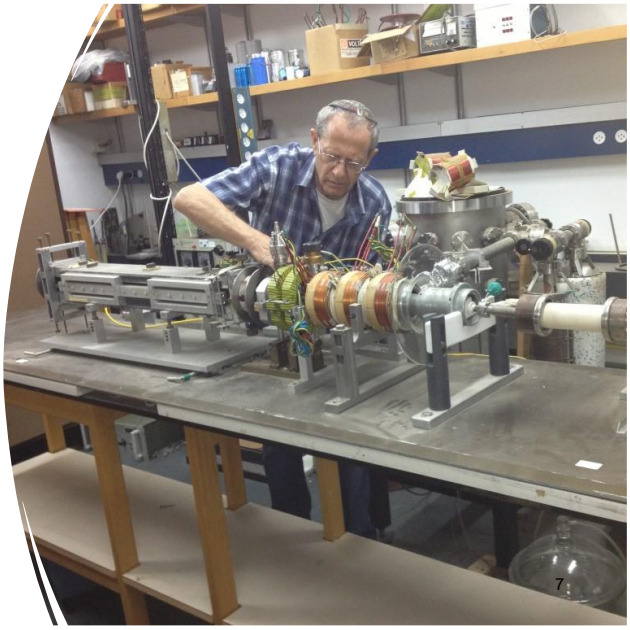

Fig 4: : Free Electron Maser (FEM) experimental system at Tel Aviv University. The photograph shows the system at the stage when laboratory engineer Haim Kleinman dismantles the facility in preparation for its transfer to Ariel. Today, the facility is placed in the visitor center at the entrance to the accelerator center in Ariel, and is used to demonstrate the operating principles of the Superradiant FEL.

The W. I. Tandem van der Graff ion Accelerator

6->12 MeV electrostatic accelerator.
Donated as part of the German compensation agreement by K. Adenauer (1954).

First lasing 1997:

Abramovich, A., A.Arensburg D. Chairman, A. Eichenbaum, M.Draznin, A. Gover, H. Kleinman et al.
"Lasing and radiation-mode dynamics in a Van de Graaff accelerator-free-electron laser with an internal cavity."
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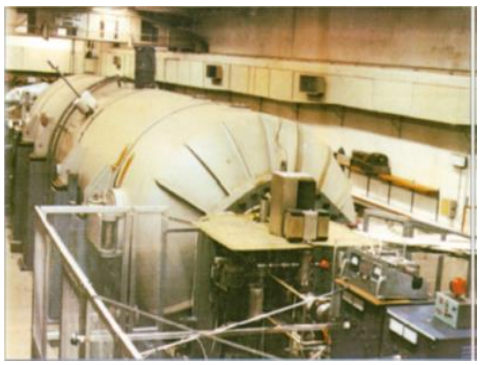

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Fig 5: The first FEL facility at the Weizmann Institute built by the FEL consortium after converting an electrostatic ion accelerator (TANDEM van der Graaff) to an electron accelerator. The first millimeter wave ring was demonstrated in Hanukkah 1997.

4. Moving the Tandem-FEL project to Ariel

Fig 6: Crain taking out the Tandem Accelerator from the Weizman Institute by "Avi Manofim".

Fig 7: Yigal Cohen-Orgad in the background of the accelerator after its transfer to Ariel, on his right - Gover and Sokolovsky, on his left - the team of Romanian accelerators experts who packaged the accelerator.

Fig 8: The tandem accelerator in its new residence in the accelerator building in Ariel. The aluminum tube at the end of the accelerator conducts the FEL radiation into the radiation users room through a protective wall 1.5m wide. Standing next to the accelerator Mickey Kanter, the accelerator engineer.

Fig 9: The visit of the Minister of Science Raleb Majadla to the FEL center in 2009. In the photo, Prof. Dan Meirstein - president of the college, Yigal Cohen-Orgad, Prof. Avraham Gover - head of the center, minister Rafi Eitan.

Fig 10: Professor Gover receiving the FEL Award for 2005 at the International FEL Conference at Stanford for his contribution to the development of the Superradiant FEL concept (which later formed the basis for the construction of the THz Superradiant FEL at the Ariel Accelerator Center). Standing next to him are John Galayda, chairman of the conference (to his right), Alexander Van der Meer, chairman of the award committee (to his left.)

http://www-ssrl.slac.stanford.edu/lcls/fel2005/index.php

5. The THz Superradiant FEL based on an RF-LINAC accelerator

6. Status update of the Accelerators center and the FEL project 2022

Fig 11: ORGAD accelerator (*Optically-pumped RF-Gun Accelerator Device)*

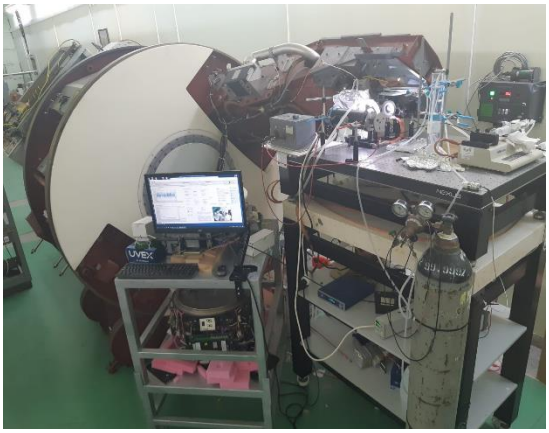

Fig 12: Accelerator for radiation chemistry applications.

Fig 13: A third floor construction project in the accelerator center. Funding donated by the Schlesinger family: Starting construction in 2022.

Fig 14: The planned structure of the accelerator center and the visitor lobby. Completion target 2024.

Fig 15: A didactic model for explaining the principles of operation of FEL and SUPERRADIANT-FEL in the visitors' lobby by Mickey Kanter. The model is based on the Free Electron Maser (FEM) experimental system of Tel Aviv University (Figure 4) which was transferred to Ariel.

Fig 16: The Israeli Superradiant THz FEL facility October 2022. In the far sections - the ORGAD accelerator, in the near sections - the Magnetic Wiggler and the radiation out coupling. Standing from left to right: Ariel Naus, Avraham Gover, Aharon Friedman, Yehiel Vashdi

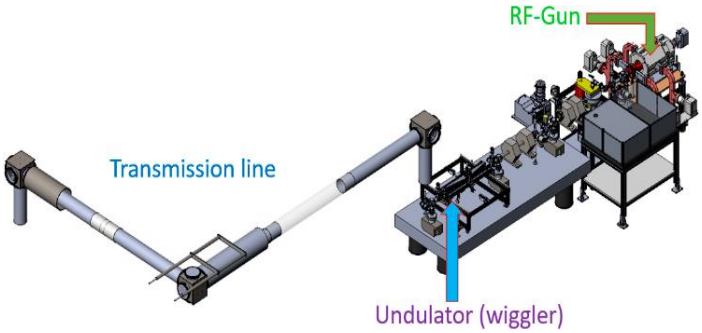

Fig 17: The THz radiation source and the radiation transfer line from the accelerator hall to user rooms.

Fig 18: First measurement of superradiative THz radiation on Oct 31, 2022

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