FREE ELECTRON LASERS

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Proceedings of the Eleventh International
Free Electron Laser Conference
Naples, FL, USA, August 28 – September 1, 1989

Sponsored by the IEEE Lasers and Electro-Optics Society

Editors

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CREOL, Orlando, FL, USA

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PREFACE

These Proceedings contain a selection of papers presented at the Eleventh International Free Electron Laser (FEL) Conference. The Conference was held August 28–September 1, 1989 in Naples, on the Gulf-of-Mexico coast of Florida.

A record of more than 130 papers were presented at the conference. The quantity and contents of the presentations represent a simultaneous increase in specialization and broadening of the field of FELs. In particular, FELs are entering a new developmental phase in which considerable technological improvements in undulator field quality, electron source beam quality and diagnostics have occurred. Moreover, the dedication of a whole session to applications of FELs attests to the coming of age of our field.

The keynote address was delivered by John Madey, first recipient of the International FEL Prize (1988). His presentation addressed four issues: (1) the nature of the FEL revolution, (2) present (1990) research directions of FELs, (3) accomplishments in 1989 and (4) how to proceed in an indifferent and chaotic world.

In the plenary session, V.N. Litvinenko reported the operation of the shortest-wavelength FEL. Using VEPP-3, an electron storage ring at Novosibirsk, the USSR team demonstrated optical-klystron FEL operation in the 240–690 nm region.

In recognition of his outstanding contributions to the understanding of the free electron laser mechanism, the 1989 FEL Prize was awarded to William Colson during the Conference Banquet. In the words of a member of the awarding committee: "Bill laid the foundation for the classical theory of the free electron laser, enabling a wide audience to understand the operating principles of FELs".

The Conference was sponsored by the IEEE Laser & Electro-Optics Society (LEOS), the Office of Naval Research, the Air Force Office for Scientific Research, the SDIO Medical FEL Program and the Center for Research in Electro-Optics and Lasers (CREOL) of the University of Central Florida. TRW provided the funds for the 1989 FEL Prize.

We are very thankful to the many people who helped us organize and run the Conference. Special thanks are due to Elisa Meza (CREOL), Judy Jensen (LLNL) and the very efficient IEEE-LEOS staff of Bob Wangemann, Wendy Rochelle and Glenda McBride.

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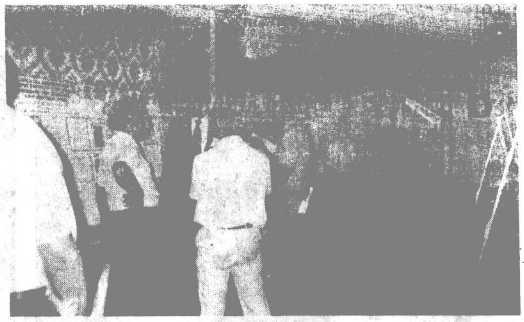













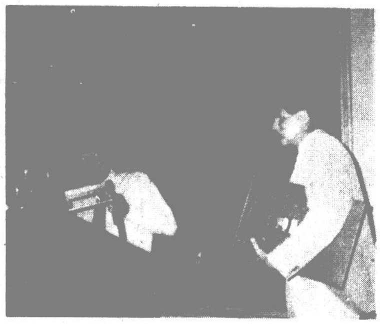

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Section I. Existing experiments

THE VEPP-3 STORAGE-RING OPTICAL KLYSTRON: LASING IN THE VISIBLE AND ULTRAVIOLET REGIONS

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Lasing in a wide spectral range (from visible to ultraviolet, 2400–6900 Å) was reached in the optical klystron OK-4 installed on the VEPP-3 storage ring. OK-4 is the first FEL operating in UV.

1. Introduction

The optical klystron was proposed in 1977 by Vinokurov and Skrinsky [1] as a modification of a free electron laser (FEL). It has a much higher gain per pass than a FEL, due to using a special device – a buncher located between two undulators. Experiments with an optical klystron (OK) have been carried out at our Institute since 1979.

In late 1985 it was decided to update the VEPP-3 storage ring. One of the most important tasks of this modernization was to install an additional straight section (bypass) dedicated to OK operation. In March 1988 the bypass was successfully installed on VEPP-3, in April a circulating electron beam was captured and on June 3 lasing was attained and wavelength tunability from 5800 to 6900 Å, with a line width less than 0.6 Å, was achieved. In July and October 1988 lasing in the violet (3750–4600 Å) and ultraviolet (2400–2700 Å) ranges was also obtained [3].

2. A bypass on the VEPP-3

The scheme of the VEPP-3 storage ring with the bypass is shown in fig. 1. The bypass consists of two bending magnets, twelve quadrupoles, a vertical wiggler and an OK magnetic system of 7.8 m length. The bypass focusing system is very flexible and it gives us a possibility to optimize the electron-beam parameters in the OK and to match η- and β-functions with VEPP-3 arcs under different conditions.

3. OK magnetic system

The OK magnetic system comprises two electromagnetic undulators with a buncher (3-pole wiggler) between them. The cross sections of the undulator are schematically shown in fig. 2 and its parameters are given in table 1.

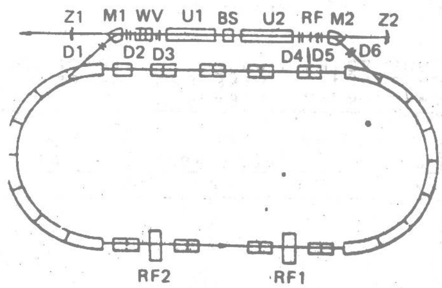

Fig. 1. Layout of the VEPP-3 storage ring with the bypass: M1, M2 – bending magnets; D1–D6 – quadrupole lenses; U1, U2 – undulators; BS – bunching section; WV – vertical wiggler; RF – 1.2 GH_2 passive rf cavity; RF_1 – 8 MH_2 rf cavity ($q = 2$, $U_{fh} = 12$ kV); RF2 – 72 MHz rf cavity ($q = 2$, $U_m = 12$ kV); RF2 – 72 MHz rf cavity ($q = 18$, $U_{fh} = 600$ kV); Z1, Z2 – optical cavity mirrors.

The field in the undulator is excited by eight periodically bent copper buses with holes for water cooling. The buses are commuted on the ends of the undulator.

Each undulator has 68 poles; the ones on both ends are wound by one turn and they have half the magnetic potential. Undulators are installed on the bypass one after another and are bilaterally symmetric about the centre of the section between them. This automatically provides absence of any equilibrium orbit distortion in the storage ring.

The electromagnetic undulators allow a wavelength of fundamental harmonics tunability from 1000 up to 15 000 Å by changing the magnetic field (at 350 MeV fixed energy), i.e. by changing the *K*-factor.

The gain values were measured by comparing with

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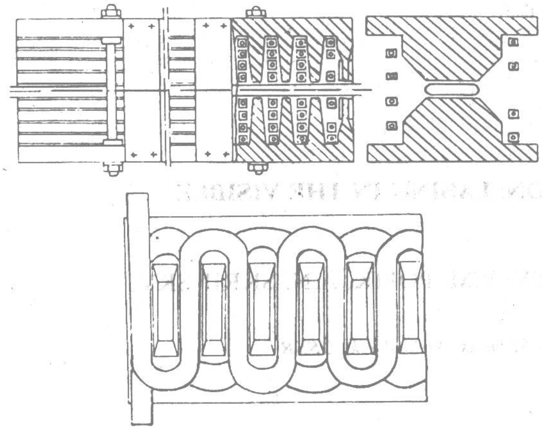

Fig. 2. Cross section of the OK-4 undulator.

the optical cavity losses on the edges of the reflection bands, where lasing was stopped: 10% at 6000 Å, 5.5% at 4000 Å and 3.5% per pass at 2500 Å.

4. Lasing in the OK

When the OK is tuned above threshold, i.e. the OK gain is more than the optical-cavity losses and the revolution frequencies of the electron and light beam are synchronized, the lasing appears on a wavelength where the OK has a maximum gain. Some of the measured spectra are shown in fig. 3.

Table 1
Parameters of the OK-4 undulator

Undulator length [m]	3.4
Number of periods	33.5
Period [cm]	10
Magnetic gap [cm]	2.2
Maximum magnetic field along the axis [kG]	5.3 (5.7)
Pole transverse width [cm]	9
Number of separate buses	8
Cross section of a bus [mm^2]	18 × 18
Current consumption [kA]	2.2 (3)
Power consumption [kW]	60

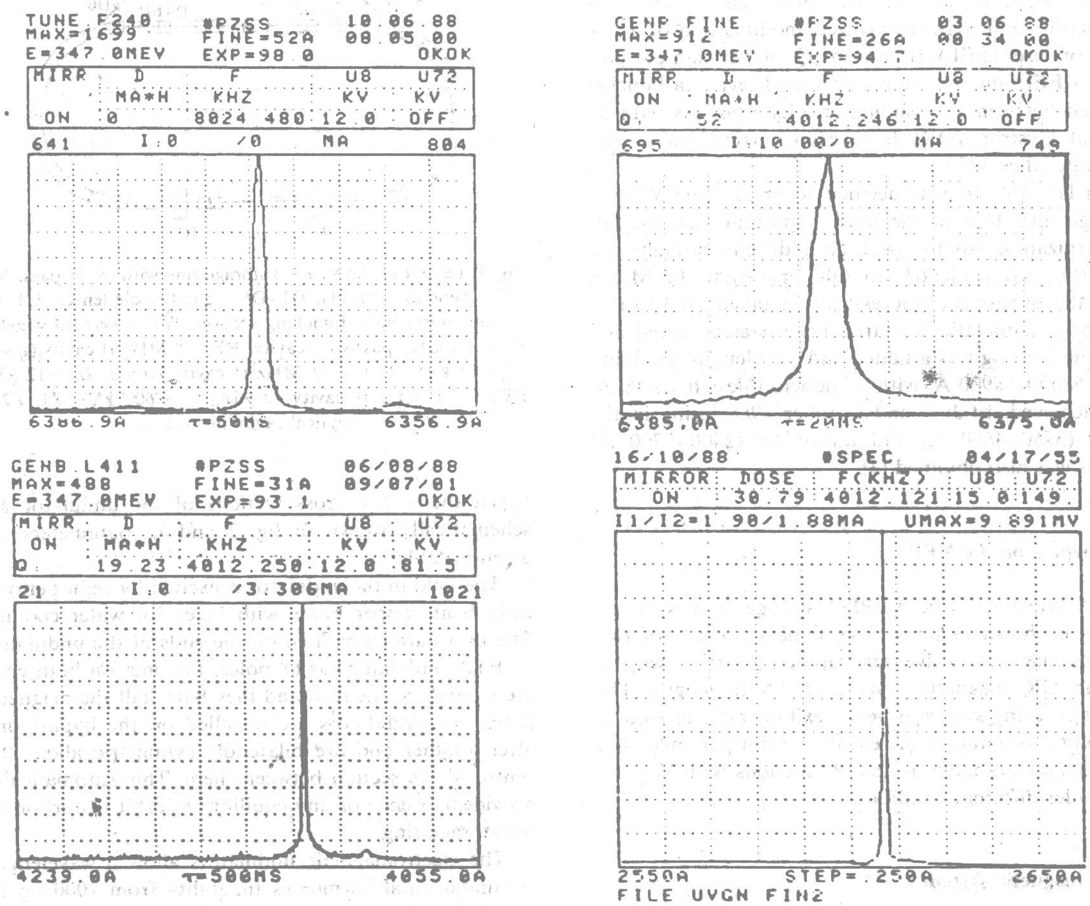

Fig. 3. Lasing lines in the red, violet and ultraviolet spectral regions, obtained on the OK-4.