Book of abstracts

PHOTONICA2021

VIII International School and Conference on Photonics

& HEMMAGINERO workshop

23 - 27 August 2021,

Belgrade, Serbia

Editors

Mihailo Rabasović, Marina Lekić and Aleksandar Krmpot

Institute of Physics Belgrade, Serbia

Belgrade, 2021

ABSTRACTS OF TUTORIAL, KEYNOTE, INVITED LECTURES, PROGRESS REPORTS AND CONTRIBUTED PAPERS

of

VIII International School and Conference on Photonics PHOTONICA2021

23 - 27 August 2021

Belgrade Serbia

Editors
Mihailo Rabasović, Marina Lekić and Aleksandar Krmpot

Publisher
Institute of Physics Belgrade
Pregrevica 118
11080 Belgrade, Serbia

Printed by
Serbian Academy of Sciences and Arts

Number of copies
200

ISBN 978-86-82441-53-3

CIP - Каталогизација у публикацији - Народна библиотека Србије, Београд

535(048)

621.37/.39:535(048)

621.37/.39:535]:61(048)

66.017/.018(048)

INTERNATIONAL School and Conference on Photonic (8; 2021; Beograd)

Book of abstracts / VIII International School and Conference on Photonics PHOTONICA2021 & HEMMAGINERO workshop, 23 - 27 August 2021, Belgrade, Serbia; editors Mihailo Rabasović, Marina Lekić and Aleksandar Krmpot. - Belgrade: Institute of Physics, 2021 (Belgrade: SASA). - V, 192 str.: ilustr.; 30 cm

Tiraž 200. - Bibliografija uz većinu apstrakata. - Registar.

ISBN 978-86-82441-53-3

1. Hemmaginero Workshop (2021; Beograd)

а) Оптика -- Апстракти б) Оптички материјали -- Апстракти в) Оптоелектроника -- Апстракти г) Оптоелектроника -- Биомедицина -- Апстракти д) Телекомуникације -- Апстракти

COBISS.SR-ID 44290057

Frequency combs generated by a Bloch gain induced giant Kerr nonlinearity

N. Opacak[1], S. D. Cin[1], J. Hillbrand[2], G. Strasser[1] and B. Schwarz[1]
[1]*Institute of Solid State Electronics, Technische Universität Wien, Gußhausstraße 25-25a Vienna, Austria*
[2]*Institute for Quantum Electronics, ETH Zurich, 8093 Zurich, Switzerland*
e-mail:nikola.opacak@tuwien.ac.at

Optical nonlinearities are known to coherently couple the amplitude and the phase of light, which can lead to the formation of perfectly periodic waveforms – known as frequency combs (FCs). Recently, self-starting frequency combs that do not rely on the emission of short pulses are appearing in numerous semiconductor laser types, among which is the quantum cascade laser. This novel type of combs is gaining vast attention from researchers due to their self-starting nature and compactness, making them an ideal platform for further development of spectroscopic applications. Their spontaneous formation was explained through an interplay of phenomenological nonlinearity and dispersion in the laser active region [1], although the actual physical processes remained unclear until now. Here we show that Bloch gain – a phenomenon described by Bloch and Zener in the 1930s – plays an essential role in their formation.

We develop a self-consistent theoretical model which couples every aspect of the laser operation – from the electronic band structure and carrier transport, to the spatio-temporal evolution of the electric field inside the laser cavity [2]. We demonstrate that a Bloch gain contribution is present in any laser and becomes dominant under saturation, shown in Fig. 1a). It deviates the gain strongly towards an asymmetric shape, which yields a giant Kerr nonlinearity of $\sim 10^{-15}$ m^2/W and explains the nonzero linewidth enhancement factor [3]. The induced Kerr nonlinearity serves as an efficient locking mechanism and results in the formation of FCs in Fabry-Perot laser cavities (Fig. 1.b). In ring resonators, it leads to the emission of localized structures [4], akin to dissipative Kerr solitons.

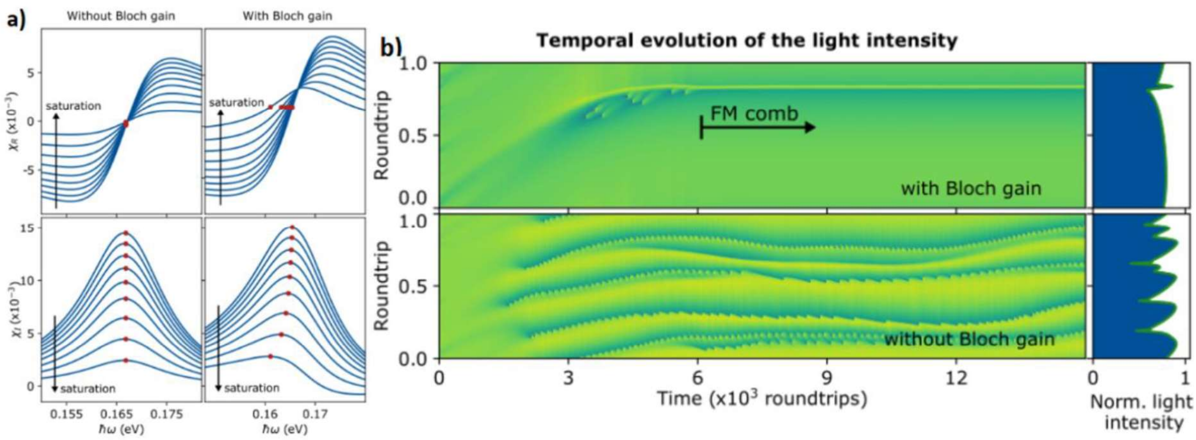

Figure 1. a) Complex susceptibility of the laser active medium with the increase of the laser intensity. b) Temporal evolution of the light intensity inside the laser cavity. Inclusion of the Bloch gain leads to the formation of a stable frequency modulated (FM) comb. Omitting it results in an unlocked state.

REFERENCES

[1] N. Opačak, B. Schwarz, Phys. Rev. Lett. 123, 243902 (2019).
[2] N. Opačak, S. D. Cin, J. Hillbrand et al., arXiv 2102.08167 (2021).
[3] N. Opačak, F. Pilat, D. Kazakov et al., arXiv 2104.05747 (2021).
[4] M. Piccardo, B. Schwarz, D. Kazakov et al. Nature 582, 360 (2020).