EFFECT OF THE CAVITY LENGTH IN A RAMAN LASER WITH THE MULTIMODE PUMP

R. Chulkov[1], V. Markevich[1], A. Alyamani[2], E. Cheshev[3], V. Orlovich[1]

[1] B.I. Stepanov Institute of Physics, NAS of Belarus, Minsk, Belarus
[2] King Abdulaziz City for Science and Technology (KACST), Riyadh, Germany
[3] Physical Institute of the Russian Academy of Sciences, Moscow, Russia
E-mail: ruslan.chulkov@gmail.com

Solid-state Raman lasers (SSRLs) are considered as a cost-efficient and compact solution which is traditionally used for extension of a spectral range of the mode-locked and Q-switched lasers [1, 2]. The diffraction losses and round-trip time are two key characteristics of a Raman laser cavity (RLC) which are known to severely affect the threshold and efficiency of the SSRL generation [3, 4]. In this report, we reveal the third factor that should be taken into account when SSRL is optically pumped by radiation of a longitudinally-multimode Q-switched laser. This factor determines the relation between the lengths of the pump laser cavity and RLC.

At excitation of stimulated Raman scattering in a 7 cm length barium nitrate crystal by the frequency-doubled 7 ns pulses of a commercial side-diode-pumped actively *Q*-switched Nd:YAG laser, we experimentally observe the 30 % decrease in the generation threshold and a substantial increase in the Stokes conversion efficiency with respect to their nominal values when the optical length of the RLC is equal to the pump cavity length (Fig. 1). The threshold reduction and efficiency enhancement are also observed when the RC length approaches the half-length of pump cavity or is related to that as 2/3. The 1st Stokes generation dynamics at the length matching is found to resemble the mode locking that manifests itself as a regular train of spikes,

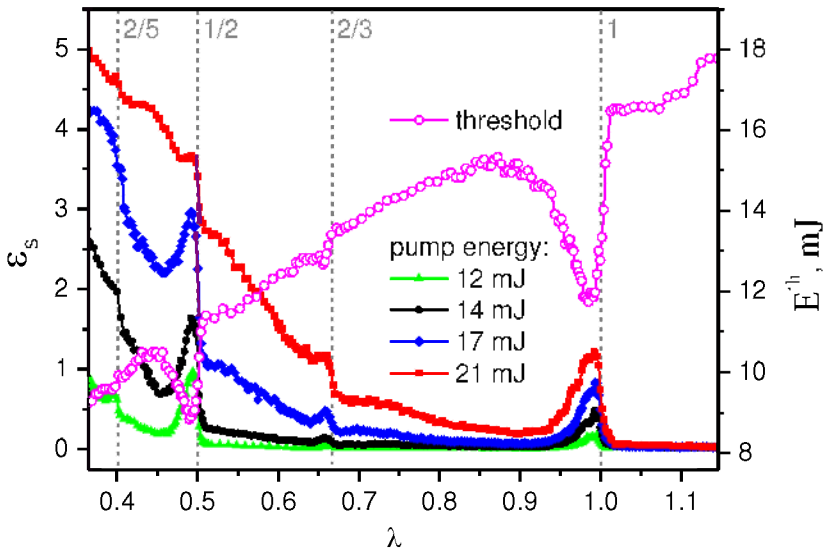

Fig. 1. Generation threshold E^{th} and conversion efficiencies ε_S of the Raman laser measured at different pump energies E_p as the functions of the normalized optical length λ

duration of which is limited to a temporal response of 0.3 ns of the registration system (Fig. 2).

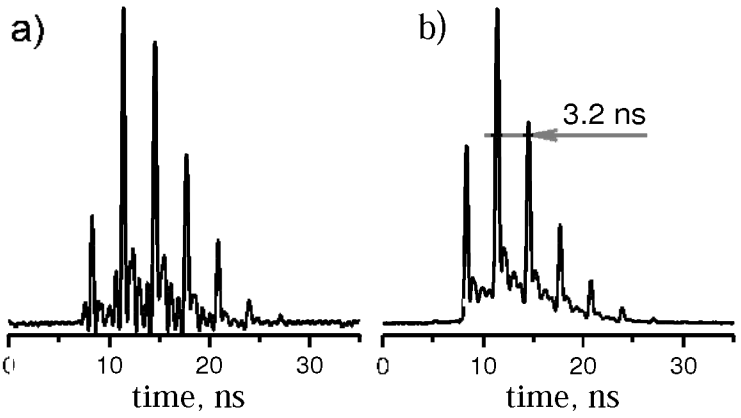

Fig. 2. Typical single-shot (*a*) and averaged over 1000 laser shots (*b*) oscilloscope traces of the Stokes pulses captured when $\lambda = 1$ and $\varepsilon_S \approx 1$ %

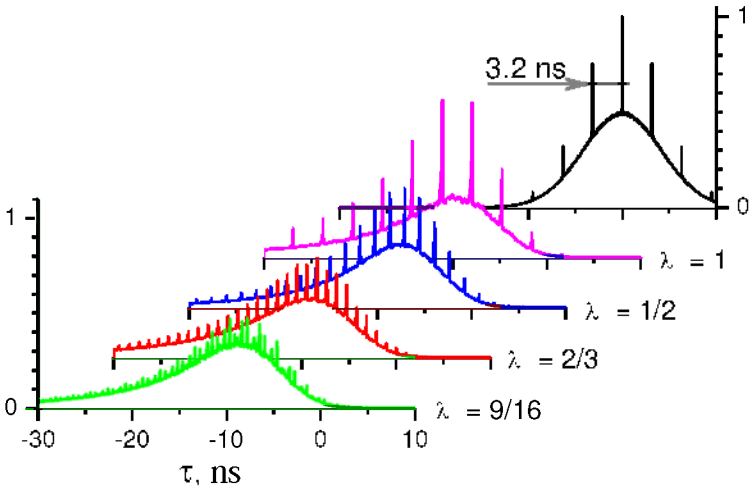

Fig. 3. Normalized CCC traces for the pump pulse and 1st Stokes pulses numerically generated at different λ values. Auto-correlation intensity trace of the pump pulse is shown on top as well.

All the observations are treated in terms of the cross-correlation coefficients (CCCs) for the Stokes and pump intensities. We show numerically that the CCC is resonantly enhanced at the length matching owing to the periodicity property [5] of the auto-correlation functions for the multimode laser field (Fig. 3). Such periodicity leads to origin of the synchronous pump effect when small-scale noisy intensity structure of the multimode pump pulse is superimposed onto the Stokes pulse intensity. This considerably enhances the Stokes gain even if the pump modes are perfectly unlocked. The results reported are of practical importance to seize upon a full potential of commercial *Q*-switched lasers and extend their spectral range by means of Raman frequency conversion.

1. *Černý P., Jelínková H., Zverev P.G., Basiev T. T.* // Prog. Quant. Electron. 2004. V. 28, P. 113.
2. *Pask H.M., Dekker P., Mildren R.P., et al.* // Prog. Quant. Electron. 2008. V. 32, P. 121.
3. *Lisinetskii V.A., Bus'ko D.N., Chulkov R.V., et al.*// J. Appl. Spectr. 2008. V. 75, P. 300.
4. *Repasky K.S., Brasseur J.K., Meng L., Carlsten J.L,* // JOSA B 1998. V. 15, 1667.
5. *Ахманов С.А., Дьяков Ю.Е., Чиркин А.С.* Введение в статистическую радиофизику и оптику. М.: Наука. 1981. 640 с.