

## Comment on 'Evidence of slow-light effects from rotary drag of structured beams'

This content has been downloaded from IOPscience. Please scroll down to see the full text.

2014 New J. Phys. 16 038001

(<http://iopscience.iop.org/1367-2630/16/3/038001>)

View [the table of contents for this issue](#), or go to the [journal homepage](#) for more

Download details:

IP Address: 92.42.30.206

This content was downloaded on 12/12/2016 at 21:32

Please note that [terms and conditions apply](#).

You may also be interested in:

[Evidence of slow-light effects from rotary drag of structured beams](#)

Emma Wisniewski-Barker, Graham Gibson, Sonja Franke-Arnold et al.

[Reply to Comment on 'Evidence of slow-light effects from rotary drag of structured beams'](#)

Emma Wisniewski-Barker, Graham Gibson, Sonja Franke-Arnold et al.

[Experimental investigation of the transient dynamics of slow light in ruby](#)

Emma Wisniewski-Barker, Graham M Gibson, Sonja Franke-Arnold et al.

[Theoretical analysis and experiment performance of slow-light based on stimulated Brillouin scattering \(SBS\)](#)

Hongyan Zhou, Kun Zhong, Ru Zhang et al.

[Light propagation through atomic vapours](#)

Paul Siddons

[Reduction of Light Group Velocity by Coherent Population Oscillation in a Ruby Crystal](#)

Zhang Yun-Dong, Fan Bao-Hua, Yuan Ping et al.

[Subluminal light propagation through an ultracold atom–molecule coupled resonant medium](#)

Sandeep Sharma, Bimalendu Deb and Tarak N Dey

[Atomic frequency comb storage as a slow-light effect](#)

M Bonarota, J-L Le Gouët, S A Moiseev et al.

## Comment

# Comment on ‘Evidence of slow-light effects from rotary drag of structured beams’

**G G Kozlov, S V Poltavtsev, I I Ryzhov and V S Zapasskii**

Saint-Petersburg State University, Physics Department, Spin Optics Laboratory,  
Saint-Petersburg, 198504 Russia

E-mail: [vzap@rambler.ru](mailto:vzap@rambler.ru)

Received 8 November 2013, revised 5 February 2014

Accepted for publication 3 March 2014

Published 28 March 2014

*New Journal of Physics* **16** (2014) 038001

doi:[10.1088/1367-2630/16/3/038001](https://doi.org/10.1088/1367-2630/16/3/038001)

### Abstract

The paper Wisniewski-Barker E *et al* (2013 *New J. Phys.* **15** 083020) is intended to distinguish experimentally between two mechanisms of pulse delay in ruby and to provide evidence in favor of the slow-light model. The proposed test is based on the idea of monitoring time delay of a ‘dark pulse’ or ‘intensity null’, rather than that of some Gaussian-like pulse. We show that, because of certain experimental inconsistencies, the results of the measurements do not allow one to prefer one of the models and, thus, are interpreted inadequately. In this comment, we propose and realize a simple modification of the experiment Wisniewski-Barker E *et al* (2013 *New J. Phys.* **15** 083020), which allows us to unambiguously resolve this dilemma. We show that the effect of pulse delay in ruby is perfectly described by the simple model of pulse reshaping and does not require invoking the coherent population oscillation-based slow-light effects.

Keywords: slow light, group velocity, saturable absorber

## 1. Introduction

The recently published paper [1] is intended to provide evidence of slow-light effects in ruby crystal. The laser pulse delay in ruby, according to [1], may result not only from trivial



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

reshaping of the pulse in a saturable absorber, but also from steep dispersion of the phase index in the vicinity of the narrow spectral dip produced in the absorption spectrum of the crystal through the effect of coherent population oscillation (CPO). To distinguish between these two mechanisms, the authors proposed to study behavior of the ‘intensity null’ in a strong laser pulse, which should essentially differ for the two models of pulse delay.

We completely agree with the main idea of the paper that, in the case of reshaping, the transmitted light intensity should vanish at zero intensity of the incident light. We also agree that, ideally, the way proposed by the authors to check it (with a dip in the pulse center) may work. But what is crucially important for such an experiment is that the light intensity in the tested point should really be zero (to within the experimental accuracy), because, otherwise, the residual incident light will probe the varying transmission of the medium, and the experiment will lose its original sense. In addition, if, as the authors assert, ‘the two mechanisms are practically indistinguishable when the input is a single pulse’, it is difficult to believe that they will become distinguishable when a single pulse is replaced by two successive pulses. It is clear (and can be easily confirmed by appropriate calculations [2]) that the dip of a two-humped pulse with no real ‘intensity null’ will be inevitably delayed in a bleachable absorber without any slow-light effects. Thus, as seen from the presented photometric curves, the experimental observations of [1] qualitatively correlate with the model of reshaping, and the delay of the pulse dip cannot serve as an ‘evidence of slow-light effects’.

It should be also noted that the employed visual representation of the results additionally disorient the reader, because what we see is the drag of bright regions, while what we want to observe is the drag of a thin dark line, which is, evidently, not the same.

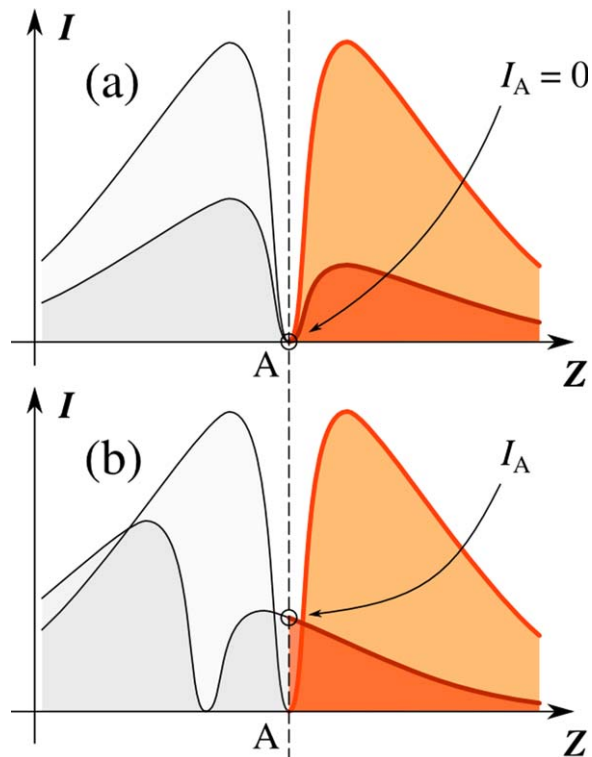
So, we have to admit that the main goal of the experiment has not been achieved because of inappropriate realization of a sound idea. In this paper, we present, as we believe, a possible simple implementation of such an experiment.

Perhaps the authors are right that it is not easy to create a dip with the ‘intensity null’ in the temporal profile of a laser pulse, but it is much more important that this dip is not needed to realize the authors’ idea. The ‘intensity null’ in the incident pulse is actually needed to check whether the transmitted light intensity *at this moment* is zero or not, rather than to measure the dip shift.

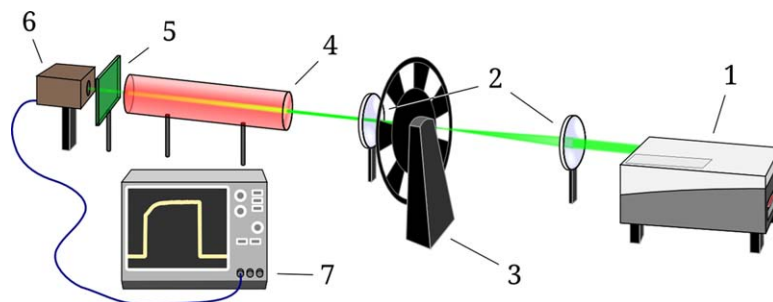
Figure 1 shows a fragment of figure 1 from [1] illustrating transformation of the pulse with ‘intensity null’ expected for the models of optical bleaching (a) and group velocity reduction (b). The two pictures are indeed essentially different. Note, however, that the second (left) half of the pulse after ‘intensity null’ does not play any role in this experiment because it cannot affect the measured value of light intensity at the point of interest A (just for causality reasons). Therefore, this part of the pulse may be readily removed together with all the problems of creating ‘intensity null’ in temporal domain. As a result, we come to the experiment with a single pulse presented by right sides of the pictures (highlighted in figure 1). Our task is to check whether the output pulse intensity  $I_A$  at point A (where the input intensity is blocked) vanishes or not. Below we describe such an experiment and its results.

## 2. Experimental

Schematic of the experimental setup is shown in figure 2. The laser beam with the wavelength  $\lambda = 532$  nm was preliminarily focused and modulated by a chopper in its waist ( $f \approx 30$  Hz).

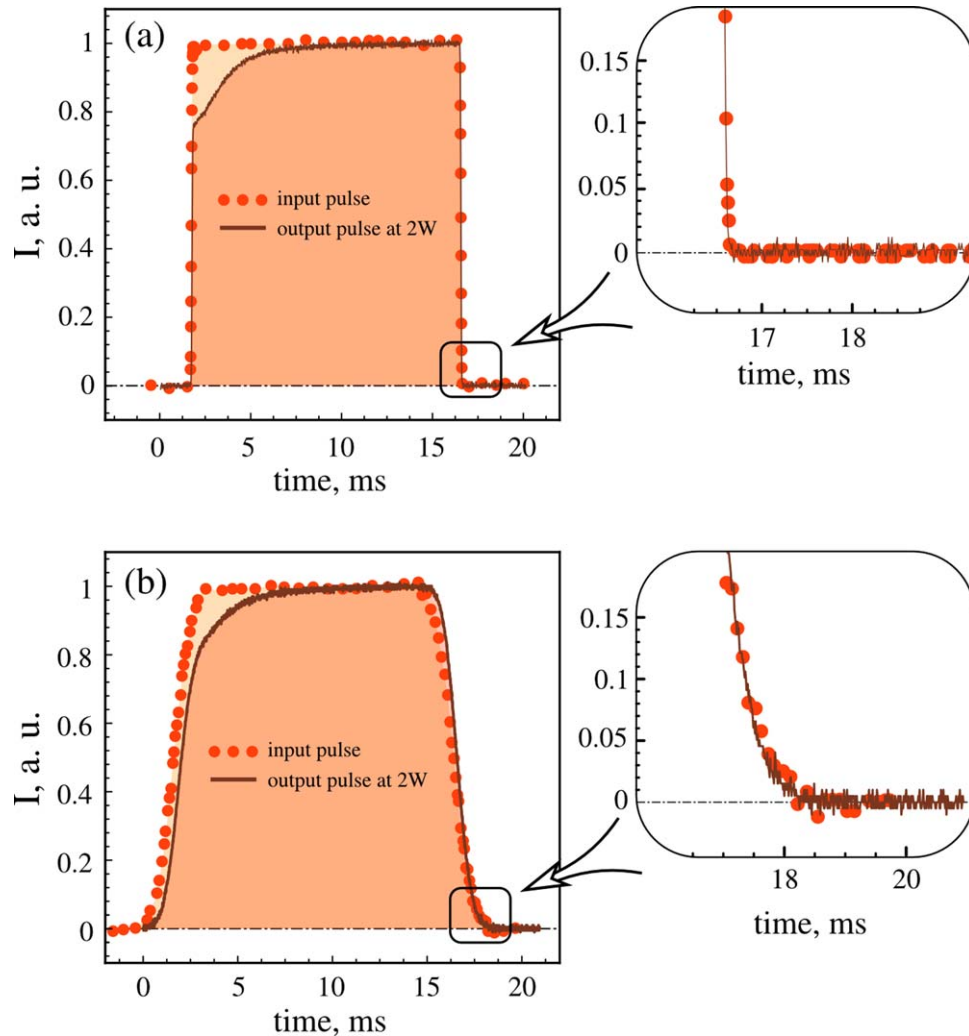


**Figure 1.** Distortion of the incident pulse passing through a bleachable absorber (according to [1]) for the models of pulse reshaping (a) and group velocity reduction (b). Figure (a), unlike appropriate picture in [1], is drawn neglecting possible contribution of fluorescence, which can be easily removed experimentally. The two models can be easily distinguished by measuring output pulse intensity at point  $A$  ( $I_A$ ), which should be essentially nonzero in the case (b).



**Figure 2.** Experimental setup. 1—diode-pumped solid state laser,  $\lambda = 532$  nm; 2—lenses; 3—chopper; 4—ruby crystal; 5—filter ZS3; 6—photodetector; 7—oscilloscope Tektronix DPO5104.

The leading and trailing edges of rectangular pulses, obtained in this way, were about  $30 \mu\text{s}$ . The light beam was then collimated (beam diameter  $\approx 0.5$  mm) and transmitted through the ruby crystal of laser quality ( $\text{Al}_2\text{O}_3 : 0.05\% \text{Cr}^{3+}$ ), 145 mm long. Temporal profile of the transmitted light at different intensities of the laser beam was detected by a photodiode and recorded by a



**Figure 3.** The measured distortion of the pulse with (a) shorter and (b) longer edges passing through a ruby crystal. Insets on the right side show magnified regions of trailing edges of the pulses. The ‘intensity nulls’ of the incident and transmitted pulses are seen to coincide perfectly within the experimental accuracy.

digital phosphor oscilloscope Tektronix DPO5104. Filter F was placed in front of the photodiode to eliminate fluorescence of the crystal.

Figure 3 shows results of the measurements. As seen from figure 3(a), distortion of the pulse with sharp edges perfectly corresponds to its expected behavior in a bleachable absorber [2]: The leading edge shows a step-wise increase with subsequent region of exponential bleaching. At the same time, the trailing edge remains undistorted, with no intensity signal after the incident light is blocked (after the ‘intensity null’). Inset in figure 3(a) illustrates with higher accuracy that no trace of the self-pumped CPO-based slow light is observed.

Additional measurements with longer edges of the pulse (just to decrease the bandwidth of the light pulse, which, according to the CPO-based slow-light model, may be of importance) also did not show any deviation from the simplest model of saturable absorber (figure 3(b)), and

intensities of the input and output light came to zero (within our experimental accuracy) simultaneously (inset in figure 3(b)).

### 3. Conclusions

In summary, we have shown that consistent experimental realization of the idea proposed in [1] confirms unambiguously the simplest model of pulse delay in a saturable absorber (known and accepted since the 1960s [3]) and leaves no room for the alternative (CPO-based) model. It should be emphasized that this simple model [2, 3] has never had any difficulties in describing dynamics of pulse propagation in a saturable absorber and did not need invoking any additional, more sophisticated, models. At the same time, the CPO-based model of self-pumped slow light [4] has never been substantiated theoretically and was repeatedly refuted in many earlier publications [2, 5–9]. We believe the authors of [1] will now agree that there are no physical grounds to connect pulse delay in ruby (as a particular case of bleachable absorber) with the CPO-based slow light.

### Acknowledgments

We acknowledge financial support from the Russian Ministry of Education and Science (contract no. 11.G34.31.0067 with SPbSU and leading scientist A V Kavokin). The work was performed using experimental equipment of the Resource Center ‘Nanophotonics’ of St Petersburg State University ([www.photon.spbu.ru](http://www.photon.spbu.ru)).

### References

- [1] Wisniewski-Barker E *et al* 2013 Evidence of slowlight effects from rotary drag of structured beams *New J. Phys.* **15** 083020
- [2] Zapasskii V S and Kozlov G G 2006 A saturable absorber, coherent population oscillations, and slow light *Opt. Spectrosc.* **100** 419–24
- [3] Selden A C 1967 Pulse transmission through a saturable absorber *Brit. J. Appl. Phys.* **18** 743
- [4] Bigelow M S, Lepeshkin N N and Boyd R V 2003 Observation of ultraslow light propagation in a ruby crystal at room temperature *Phys. Rev. Lett.* **90** 113903
- [5] Aleksandrov E B and Zapasskii V S 2006 Chasing slow light *Physics—Uspekhi* **49** 1067–75
- [6] Macke B and Segand B 2008 Slow light in saturable absorbers *Phys. Rev. A* **49** 013817
- [7] Stepanov S and Hernández E H 2008 Controllable propagation of light pulses in Er-doped fibers with saturable absorption *Opt. Lett.* **33** 2242–4
- [8] Selden A C 2009 Slow light and saturable absorption *Opt. Spectrosc.* **106** 881–8
- [9] Zapasskii V S and Kozlov G G 2009 Incoherent slow and fast light *Opt. Express* **17** 22154