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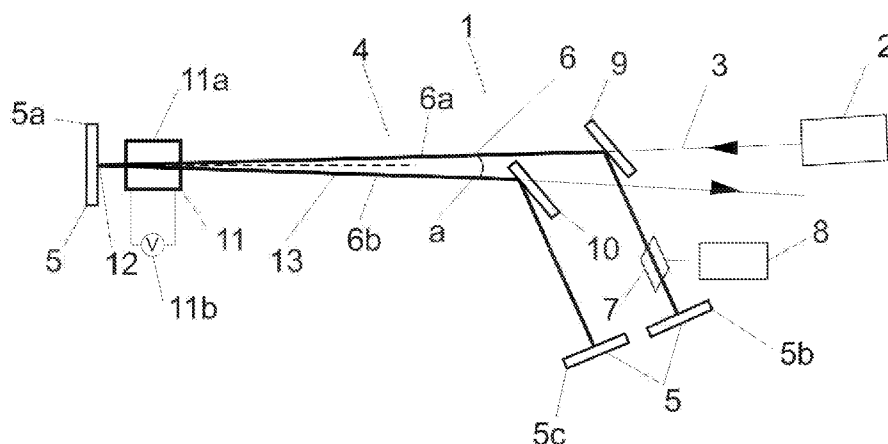


Fig. 1

(57) Abstract: Regenerative amplifier (1) and method of coupling a laser pulse (3) in and out of the regenerative amplifier (1) comprising: - a laser pulse generator (2), - a laser cavity (4) defined by mirrors (5; 5a, 5b, 5c, 5d, 5e, 5f, 5g) for passing a laser pulse (3) along a laser pulse path (6) extending between the mirrors (5; 5a, 5b, 5c, 5d, 5e, 5f), - a first gain medium (7) arranged in the laser cavity (4), - a first polarizer (9) for coupling in a laser pulse (3) having a first polarization state, - a switch element (11) for switching the laser pulse (3) from the first polarization state into a second polarization state and vice versa, - a second polarizer (10) for coupling out a laser pulse (3) having the first polarization state, wherein - the laser pulse path (6) in the laser cavity (4) comprises an input path section (6a) for coupling in the laser pulse (3) and an output path section (6b) for coupling out the laser pulse (3), wherein - the input path section (6a) is arranged at an angle (a) to the output path section (6b) such that the input path section (6a) intersects the output path section (6b) at an intersection (12), wherein - the switch element (11) is arranged such that the input path section (6a) and the output path section (6b) extend through the switch element (11).

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Regenerative amplifier and method of coupling a laser pulse in and out

The invention is related to a regenerative amplifier comprising:

- a laser pulse generator,
- a laser cavity defined by mirrors for passing a laser pulse along a laser pulse path extending between the mirrors
- a first gain medium arranged in the laser cavity,
- a first polarizer for coupling in a laser pulse having a first polarization state,
- a switch element for switching the laser pulse from the first polarization state into a second polarization state and vice versa,
- a second polarizer for coupling out a laser pulse having the first polarization state.

The invention is further related to a method for regenerative amplification of a laser pulse comprising the steps of:

- generating a laser pulse having a first polarization state,
- coupling in the laser pulse having the first polarization state into a laser cavity,
- switching the laser pulse from the first polarization state into a second polarization state by means of a switch element, thereby locking the laser pulse in the laser cavity,
- passing the laser pulse locked in the laser cavity through a gain medium arranged in a beam path of the laser pulse inside the laser cavity,
- switching the laser pulse from the second polarization state into the first polarization state,
- coupling out the laser pulse having the first polarization state from the first cavity.

As is well known in the prior art, a regenerative amplifier is a

device which is used for strong amplification of optical pulses, usually with ultrashort pulse durations in the picosecond or femtosecond domain. For this purpose, a gain medium is placed in an optical cavity. A locking device is used for controlling the number of round trips in the optical cavity. Typically, the locking device is realized with a switch, usually having an electro-optic modulator and a polarizer. The principle of operation of the regenerative amplifier is thus as follows.

- First, the gain medium is pumped for a period of time, so that it accumulates energy.
- Then, an initial pulse from a laser pulse generator is injected into the optical cavity through a port which is opened for a time shorter than the round-trip time by means of the switch.
- Thereafter, the pulse can undergo a multitude of round trips through the optical cavity, being amplified to a high energy level.
- Finally, the pulse is released from the resonator.

Thus, upon expiration of the locking time, the locking device is used for coupling out an amplified pulse from the laser cavity. A conventional set-up in the prior art provides for sending the output pulses along the same physical path as the input pulses, i.e. towards the pulse generator. Therefore, an additional input/output decoupler is required in order to geometrically separate the output port from the input port and to protect the pulse generator from perturbations and damage that may occur if the amplified pulses were passed into the pulse generator. Typically, the input/output decoupler is a passive optical device, which may comprise a magneto-optic non-reciprocal polarization rotator (Faraday cell) and a polarizer. The effect of this input/output decoupler is that the polarization of the output radiation is orthogonal to that of the input radiation. Therefore, the output radiation is rejected from the path of the input

radiation by the polarizer.

The need for an input/output decoupler increases the complexity and thus the costs of the known regenerative amplifiers. Therefore, it is of great practical importance to find a way for avoiding usage of the input/output decoupler and for geometrically decoupling the input and the output port by means of the locking device.

One possible solution to the said task is shown in the article "Nd:YAG regenerative amplifier", J. Appl. Phys. 51 (7), 3548 (1980) by J. E. Murray and W. H. Lowdermilk. It is based on employment of two separate electrooptic switches for locking the input pulse in the cavity and for outcoupling the amplified pulse from the laser cavity. The drawback of this design is that, while an optical isolator may be dispensed with, it requires a second electrooptic switch, which in turn leads to increased complexity of the known set-up.

A different solution is presented in US 2015/288134 (equivalent to WO 2014/041441 A). In this prior art, a single electrooptic switch formed by a Pockels cell is complemented with two polarizers, each of which is operated in $\lambda/2$ mode. In this set-up, one polarizer serves as an input port, while the other polarizer serves as an output port. However, the proposed design has several drawbacks. Firstly, it is crucial to locate the electrooptic switch in the center of the laser cavity, which increases the length of the laser cavity. Secondly, it requires increased operating voltage of the electrooptic switch which in turn requires more complex switching electronics. Third, increased operating voltage entails longer switching times which further increases the requirements for the length of the laser cavity.

WO 2014/108143 A1 aims to provide a regenerative laser

amplifier that enables the adjustment of parameters of the amplified laser beam. This is achieved by placing an optical element in a polarization-dependent resonator path. Depending on the state of a Pockels cell the resonator path is taken or not. In this way, the optical element can be selected to influence the pulse duration and wavelength characteristics of the laser beam. However, in this known configuration, the output path is the same or collinear to the input path, and it also has the same drawback as the variant proposed by US 2015/288134.

Another known approach is disclosed in WO 2014/008909 A1. Herein, in a first step the laser beam is coupled into a resonator path by an optical coupling device (e.g. a Pockels cell), wherein it is amplified in a multitude of run-throughs. In a second step the laser beam is coupled out of the resonator path and into a multi-pass amplifier, wherein the pulse is post-amplified, before being emitted from the device. However, the setup of this implementation is very complex, requiring more space and components.

An alternative approach is demonstrated by Yanovsky, V., C. Felix, and G. Mourou in "High-energy broadband regenerative amplifier for chirped-pulse amplification", Lasers and Electro-Optics, 2001, CLEO'01, Technical Digest, Summaries of papers presented at the Conference on 11 May 2001, IEEE, 2001. It features a ring cavity design wherein the light keeps on propagating in the same direction instead of bouncing between end mirrors as in the linear cavity design of US 2015/288134. Therefore, the requirements for the perimeter of the ring cavity are less than for the length of the respective linear cavity. However, this design still requires operation of the Pockels cell in $\lambda/2$ mode and the drawbacks associated therewith still apply.

It is therefore an object of the invention to alleviate at least some of the drawbacks associated with the prior art. The invention

may aim for providing an improved regenerative amplifier which allows for less complex outcoupling of the amplified laser pulses.

This object is achieved with a regenerative amplifier according to claim 1 and a method according to claim 13. Preferable embodiments are defined in dependent claims 2 to 12.

In the invention, the laser pulse path in the laser cavity comprises an input path section for coupling in the laser pulse and an output path section for coupling out the laser pulse. The input path section is arranged at an angle to the output path section such that the input path section intersects the output path section at an intersection. The switch element is arranged such that the input path section and the output path section extend through the switch element.

Thus, the regenerative amplifier of the invention provides for a geometric separation of the input path section, which the laser pulse takes after being coupled into the laser cavity, from the output path section, which the amplified laser pulse takes before being coupled out from the laser cavity. For this purpose, the input path section is arranged at an angle to the output path section. In this way, the regenerative amplifier of the invention may dispense with an input/output decoupler which was required in the prior art for separating the output radiation from the input radiation. In the invention, the switch element is arranged inside the laser cavity such that both the input laser pulse and the output laser pulse travel through the switch element. In operation, the input laser pulse is introduced into the laser cavity through the first polarizer, which serves as an input port of the laser cavity. The laser pulse is then locked in the laser cavity by means of the switch element. The laser cavity forms a resonator for the laser pulse. Thus, the laser pulse can undergo a multitude of round-trips in the laser cavity. At the same time, the laser

pulse is amplified by means of the gain medium inside the laser cavity. After expiry of the locking time, the amplified laser pulse may be coupled out by switching, in particular by deactivating, the switch element such that the output laser pulse may exit the laser cavity through the second polarizer. It is an advantage of this design that the input port and the output port of the laser cavity are geometrically decoupled from each other. Thus, the need for an input/output decoupler is eliminated. Furthermore, a second switch element, as provided for in some prior art designs, may be dispensed with. Thus, the regenerative amplifier of the invention preferably has but one switch element. Furthermore, the invention provides for compact laser cavity design with inexpensive and fast switching electronics.

In a preferred embodiment, the switch element has an optical axis extending in a bisector plane of the input path section and the output path section. It has been found experimentally that such alignment helps to minimize depolarization of light induced in the switch element.

In a further preferred embodiment, the angle between the input path section and the output path section is more than $0,01^\circ$ and less than 5° , preferably more than 0.5° and less than 4° , still more preferably more than 1° and less than 3° , for example essentially 2° . By choosing the angle in this range, it can be reliably ensured that the input path section is sufficiently separated from the output path section while the laser pulse passes through the switch element when undergoing a multitude of round-trips in the laser cavity.

In a preferred embodiment, the intersection between the input path section and the output path section is located at a first mirror of the laser cavity. Thus, in this embodiment the input path section and the output path section are arranged in V-shape. In

this embodiment, the intersection between the input path section and the output path section is outside the switch element. However, the switch element must be arranged sufficiently close to the intersection that the input path section and the output path section pass through the switch element. In this embodiment, particularly compact laser cavity designs may be achieved. Furthermore, this set-up is particularly simple.

For this purpose, it is preferred if the switch element is arranged adjacent to the first mirror of the laser cavity.

Preferably, a first distance between the switch element and the first mirror, in direction of propagation of the laser pulse, is less than a second distance between the switch element and the first polarizer, in direction of propagation of the laser pulse, the first distance preferably being less than one half, more preferably less than one third, still more preferably less than one fourth, of the second distance. Thus, the switch element is significantly closer to the first mirror than to the first polarizer, the latter defining the input port of the laser cavity.

In a preferred embodiment, the first mirror is a curved mirror.

In another preferred embodiment, the intersection between the input path section and the output path section is located inside the switch element. Thus, in this embodiment the input path section and the output path section are arranged in X-shape. Such arrangement may reduce the required aperture of the switch element compared to a V-shape embodiment with the same crossing angle as disclosed above.

In this embodiment, the laser cavity preferably comprises a first folding mirror, a second folding mirror and an intermediate mirror, the intermediate mirror, in direction of propagation of the laser

pulse being arranged between the first folding mirror and the second folding mirror.

In another preferred embodiment, the laser cavity comprises a first end mirror and a second end mirror, the first end mirror being arranged for reflecting back a laser pulse in the second polarization state to the first polarizer, the second end mirror being arranged for reflecting back a laser pulse in the second polarization state to the second polarizer.

In a preferred embodiment, the first gain medium is arranged between the first end mirror and the first polarizer or between the second end mirror and the second polarizer, wherein preferably a second gain medium is arranged between the second end mirror and the second polarizer or between the first end mirror and the first polarizer, respectively.

In a preferred embodiment, the switch element is an electro-optic switch element, in particular a Pockels cell. In the latter embodiment, the Pockels cell is preferably operated in $\lambda/4$ mode which reduces the voltage required for operation of the Pockels cell. Furthermore, the switching times may be reduced.

In the following, the invention will be explained by way of preferred embodiments illustrated in the drawings, yet without being restricted thereto. In the drawings:

Fig. 1 is a schematic view of a regenerative amplifier according to the present invention;

Fig. 2 is a schematic view of another embodiment of the regenerative amplifier;

Fig. 3 is a schematic view of yet another embodiment of the

regenerative amplifier; and

Fig. 4 is a schematic view of yet another embodiment of the regenerative amplifier.

Fig. 1 illustrates the operational principle of a regenerative amplifier 1. The regenerative amplifier 1 comprises, as is known in the prior art, a laser pulse generator (oscillator) 2 for generating laser pulses 3. The regenerative amplifier 1 further comprises a laser cavity 4 serving as a resonator. The laser cavity 4 receives the laser pulses 3 from the laser pulse generator 2. The laser cavity 4 is defined by an arrangement of mirrors 5 for repeatedly reflecting the laser pulse 3 along a laser pulse path 6. The regenerative amplifier 1 further comprises a first gain medium 7 arranged in the laser cavity 4. The gain medium 7 is made from a suitable solid state material. The first gain medium 7 is pumped with a pump laser 8 (schematically shown in Fig. 1) such that the first gain medium 7 accumulates energy.

In the shown embodiment, the regenerative amplifier 1 further comprises an input port formed by first polarizer 9 for coupling in the laser pulse 3 having a first polarization state. Likewise, the regenerative amplifier 1 comprises an output port formed by a second polarizer 10 for coupling out the laser pulse 3 having the first polarization state. The first polarizer 9 and/or the second polarizer 10 may each be a thin film polarizer. Furthermore, a locking device with a switch element 11 is provided inside the laser cavity 4 for switching the laser pulse 3 from the first polarization state into a second polarization state and vice versa.

In the shown embodiment, the switch element 11 comprises a Pockels cell (in the following: PC) with a crystal 11a and a voltage source 11b connected thereto. The switch element 11 may optionally comprise a quarter-wave retardation plate (in the following: QWP).

The crystal 11a of the Pockels cell is oriented such that the polarization state of the laser pulse 3 passed therethrough is maintained if the crystal 11a is in its unbiased state, while the polarization of the laser pulse 3 is transformed when voltage is applied to the crystal 11a. Therefore, the Pockels cell is essentially a switchable wave plate.

The electrooptic switch 11 is typically switching between two orthogonal linear polarization states, commonly referred to as s-polarized and p-polarized. In the shown embodiment, the Pockels cell is operating in the $\lambda/4$ mode which provides for rotation of the polarization of the laser pulse 3 by 90 degrees upon two passes through the crystal 11a. In contrast to this, the $\lambda/2$ mode of the Pockels cell in the prior art set-ups would rotate the polarization by 90 degree after a single pass.

In the shown embodiment of the switch element 11 (without QWP) the PC is switched on prior to arrival of the laser pulse 3 in order to switch the laser pulse 3 from the first polarization state into the second polarization state. After that the PC is switched off in the time the laser pulse 3 propagates towards the end mirror 5c along the path 6b. Then, the PC preserves the switched off state for the amplification cycle. Upon its expiration it is switched on again within the time frame of laser pulse propagation towards the end mirror 5b along path 6a and back, in order to switch the laser pulse 3 back into the first polarization state, and afterwards switch off again until the beginning of the next amplification cycle. Thus, in this embodiment the PC has to be switched on and off twice per amplification cycle.

In the embodiment of the switch element 11 with QWP (not shown) the PC is switched off upon arrival of the laser pulse 3. The QWP switches the laser pulse 3 into the second polarization state, thus directing the laser pulse 3 along the path 6b. Then, the PC

is switched on within the time frame of pulse propagation towards the end mirror 5c along path 6b and back, and then PC is maintained switched on for the amplification cycle, providing together with QWP lambda delay in two passes, thus preserving the laser pulse 3 in the second polarization state. Upon expiration of the amplification cycle the PC is switched off within the time frame of pulse propagation towards the end mirror 5b along path 6a and back, whereafter QWP switches the laser pulse 3 back into the first polarization state so that the laser pulse 3 can be coupled out through the output port 10. In this case switching electronics needs to switch PC on and off once per amplification cycle.

Furthermore, the arrangement of mirrors 5 defining the laser cavity 4 comprises a first end mirror 5b and a second end mirror 5c. The first end mirror 5b is arranged for receiving the laser pulse 3, if in the second polarization state, from the first polarizer 9 and reflecting the laser pulse 3 back to the first polarizer 9. Likewise, the second end mirror 5c is arranged for receiving the laser pulse 3, if in the second polarization state, from the second polarizer 10 and reflecting the laser pulse 3 back to the second polarizer 10. In the shown embodiment, the first gain medium 7 is arranged between the first end mirror 5b and the first polarizer 9.

As shown in Fig. 1, the laser pulse path 6 extending in the laser cavity 4 comprises a linear input path section 6a after the first polarizer 9 (seen in direction of propagation) for coupling in the laser pulse 3 and a linear output path section 6b before the second polarizer 10 (again seen in direction of propagation) for coupling out the laser pulse 3. The input path section 6a and the output path section 6b, when seen in direction perpendicular to the plane containing the input path section 6a and the output path section 6b, are arranged at an angle α to each other. Thus, the input path section 6a crosses the output path section 6b at an

intersection 12. The switch element 11 is arranged such that the input path section 6a and the output path section 6b pass the switch element 11. Of course, the laser pulse path 6 may have additional path sections, depending on the design of the laser cavity 4.

In the shown embodiment, the switch element 11 has an optical axis 13 extending in a bisector plane of the input path section 6a and the output path section 6b. The angle between the input path section 6a and the output path section 6b is not equal zero or 180° . Preferably, the angle α is essentially 2° .

In the embodiments of Fig. 1 and Fig. 2, the intersection 12 between the input path section 6a and the output path section 6b is arranged at an inner surface of a first mirror 5a of the arrangement of mirrors 5, the inner surface of the first mirror 5a facing the laser cavity 4. In this way, the intersection 12 is located outside the switch element 11. The input path section 6a and the output path section 6b of the laser pulse path 6 form a "V"-arrangement. In the shown embodiment, a first distance between the switch element 11 and the first mirror 5a, in direction of propagation of the laser pulse 3 (see arrows 14 in Fig. 1), is less than a second distance between the switch element 11 and the first polarizer 9, again seen in direction of propagation of the laser pulse 3. The first distance is measured from the surface of the crystal 11a of the switch element 11 first hit by the laser pulse 3 (seen in direction of propagation) and the reflecting surface of the first mirror 5a. The second distance is measured from the surface of the crystal 11a of the switch element 11 first hit by the laser pulse 3 and the reflecting surface of the first polarizer 9. Thus, the switch element 11 is significantly closer to the first mirror 5a than to the first polarizer 9. Preferably, the switch element 11 is arranged adjacent to the first mirror 5a of the laser cavity 4. In this way, both the forward and the

backward propagating laser pulse 3 fit into an aperture of the Pockels cell.

Fig. 2 illustrates a variant of the embodiment of Fig. 1. According to this variant, the first mirror 5a is a curved mirror. Furthermore, in this embodiment, a second gain medium 15 is arranged between the second end mirror 5c and the second polarizer 10.

In the embodiment of Fig. 3, the intersection 12 between the input path section 6a and the output path section 6b is located in the interior of the crystal 11a of the switch element 11, preferably essentially at the center of the crystal 11a of the switch element 11. In this way, the input wing of the laser pulse path 6 and the output wing of the laser pulse path 6 form an "X"-arrangement. In this embodiment, the arrangement of mirrors 5 defining the laser cavity 4 comprises a first folding mirror 5d, a second folding mirror 5e and an intermediate mirror 5f. The intermediate mirror 5f, in direction of propagation of the laser pulse 3, is arranged between the first folding mirror 5d and the second folding mirror 5e.

Fig. 4 is a variant of the embodiment shown in Fig. 3. In this embodiment, a second gain medium 15 is arranged between the second end mirror 5c and the second polarizer 10. Furthermore, in this embodiment the intermediate mirror 5f serves as another folding mirror. In detail, the intermediate mirror 5f, in direction of propagation, receives the laser pulse 3 from the first folding mirror 5d, reflects the laser pulse 3 to a curved mirror 5g, receives the reflection from the curved mirror 5g and reflects the laser pulse 3 to the second folding mirror 5e.

Claims:

1. Regenerative amplifier (1) comprising:

- a laser pulse generator (2),
- a laser cavity (4) defined by mirrors (5; 5a, 5b, 5c, 5d, 5e, 5f, 5g) for passing a laser pulse (3) along a laser pulse path (6) extending between the mirrors (5; 5a, 5b, 5c, 5d, 5e, 5f),
- a first gain medium (7) arranged in the laser cavity (4),
- a first polarizer (9) for coupling in a laser pulse (3) having a first polarization state,
- a switch element (11) for switching the laser pulse (3) from the first polarization state into a second polarization state and vice versa,
- a second polarizer (10) for coupling out a laser pulse (3) having the first polarization state,

characterized in that

- the laser pulse path (6) in the laser cavity (4) comprises an input path section (6a) for coupling in the laser pulse (3) and an output path section (6b) for coupling out the laser pulse (3), wherein
- the input path section (6a) is arranged at an angle (a) to the output path section (6b) such that the input path section (6a) intersects the output path section (6b) at an intersection (12), wherein
- the switch element (11) is arranged such that the input path section (6a) and the output path section (6b) extend through the switch element (11).

2. Regenerative amplifier (1) according to claim 1, characterized in that the switch element (11) has an optical axis (13) extending in a bisector plane of the input path section (6a) and the output path section (6b).

3. Regenerative amplifier (1) according to claim 1 or 2, characterized in that the angle (a) between the input path section (6a) and the output path section (6b) is more than $0,01^{\circ}$ and less than 5° , preferably more than $0,5^{\circ}$ and less than 4° , still more preferably more than 1° and less than 3° , for example essentially 2° .
4. Regenerative amplifier (1) according to any one of claims 1 to 3, characterized in that the intersection (12) between the input path section (6a) and the output path section (6b) is located at a first mirror (5a) of the laser cavity (4).
5. Regenerative amplifier (1) according to claim 4, characterized in that the switch element (11) is arranged adjacent to the first mirror (5a) of the laser cavity (4).
6. Regenerative amplifier (1) according to claim 4 or 5, characterized in that a first distance between the switch element (11) and the first mirror (5a), in direction of propagation of the laser pulse (3), is less than a second distance between the switch element (11) and the first polarizer (9), in direction of propagation of the laser pulse (3), the first distance preferably being less than one half, more preferably less than one third, still more preferably less than one fourth, of the second distance.
7. Regenerative amplifier (1) according to any one of claims 1 to 3, characterized in that the intersection (12) between the input path section (6a) and the output path section (6b) is located inside the switch element (11).
8. Regenerative amplifier (1) according to any one of claims 1 to 7, characterized in that the laser cavity (4) comprises a first end mirror (5b) and a second end mirror (5b), the first end mirror (5b) being arranged for reflecting back a laser pulse (3) in the

second polarization state to the first polarizer (9), the second end mirror (5c) being arranged for reflecting back a laser pulse (3) in the second polarization state to the second polarizer (10).

9. Regenerative amplifier (1) according to any one of claims 1 to 8, characterized in that the switch element (11) is an electro-optic switch element, in particular a Pockels cell (11a, 11b).

10. A method for regenerative amplification of a laser pulse (3) comprising the steps of:

- generating a laser pulse (3) having a first polarization state,
- coupling in the laser pulse (3) having the first polarization state into a laser cavity (4),
- switching the laser pulse (3) from the first polarization state into a second polarization state by means of a switch element (11), thereby locking the laser pulse (3) in the laser cavity (4),
- passing the laser pulse (3) locked in the laser cavity (4) through a gain medium (7) arranged in a beam path (6) of the laser pulse (3) inside the laser cavity (4),
- switching the laser pulse (3) from the second polarization state into the first polarization state,
- coupling out the laser pulse (3) having the first polarization state from the first cavity (4),

characterized in that

- the laser pulse path (6) inside the laser cavity (4) comprises an input path section (6a) and an output path section (6b), wherein
- the input path section (6a) is arranged at an angle (a) to the output path section (6b) such that the input path section (6a) intersects the output path section (6b) at an intersection (12), wherein
- the laser pulse (3) passes through the switch element (11)

when the laser pulse (3) travels along the input path section (6a) and the output path section (6b), respectively.

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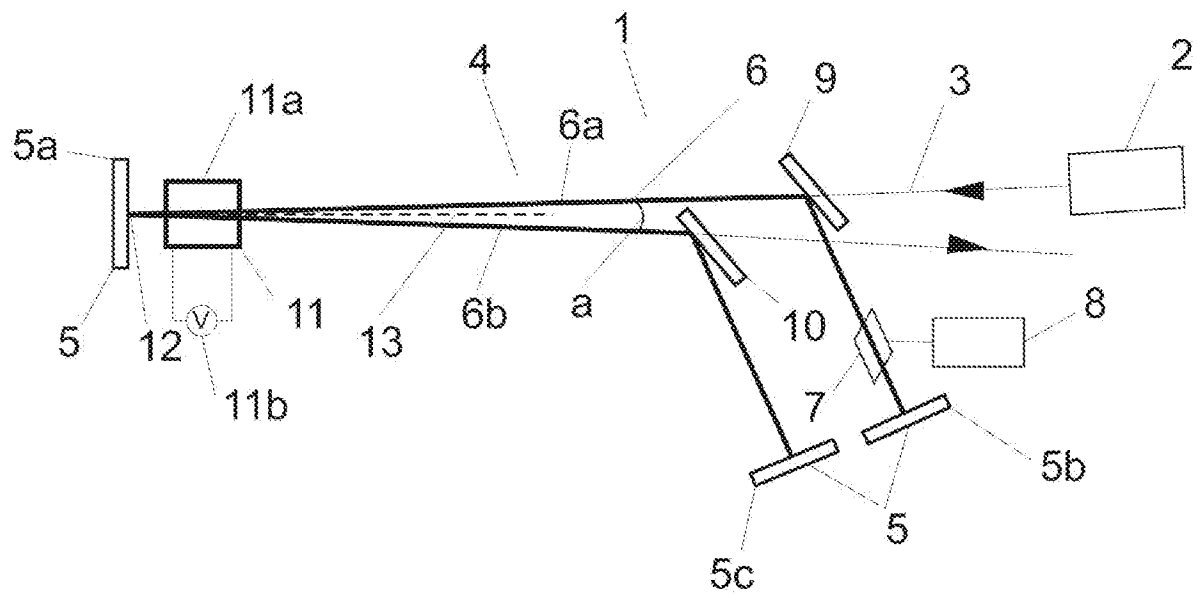


Fig. 1

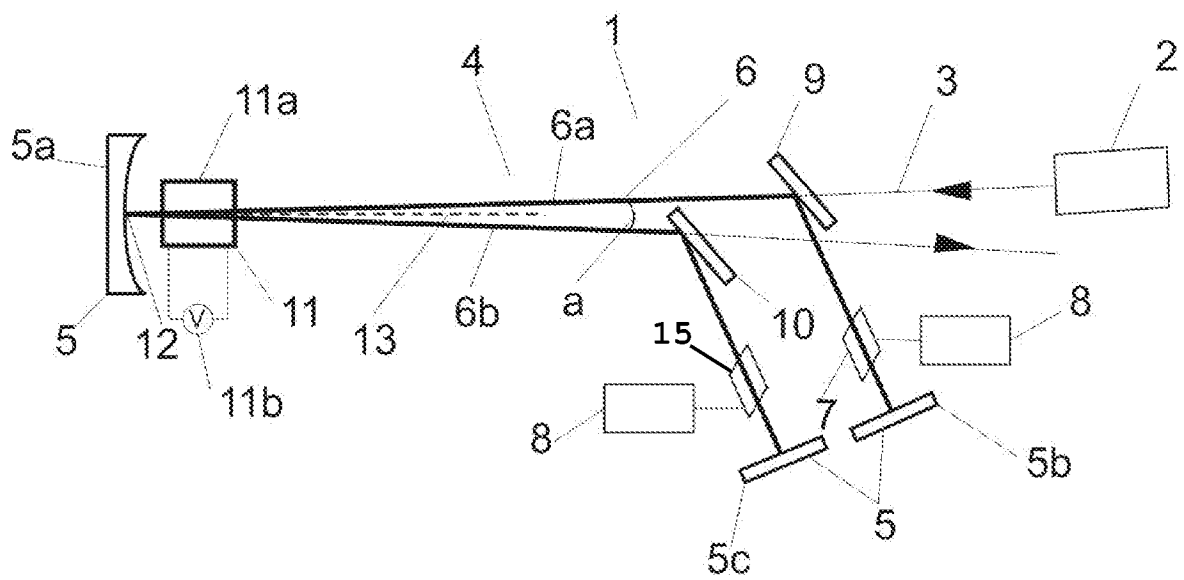


Fig. 2

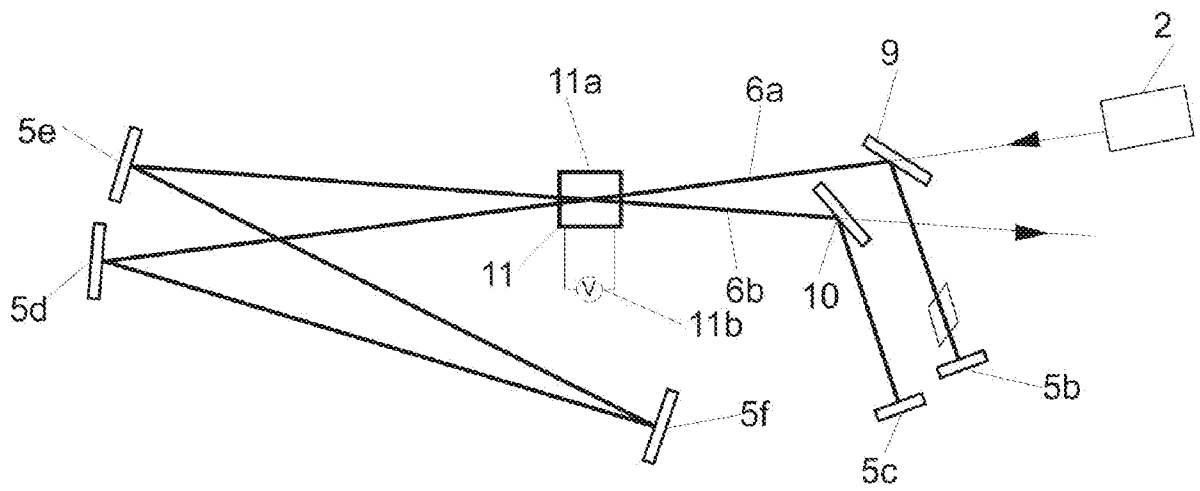


Fig. 3

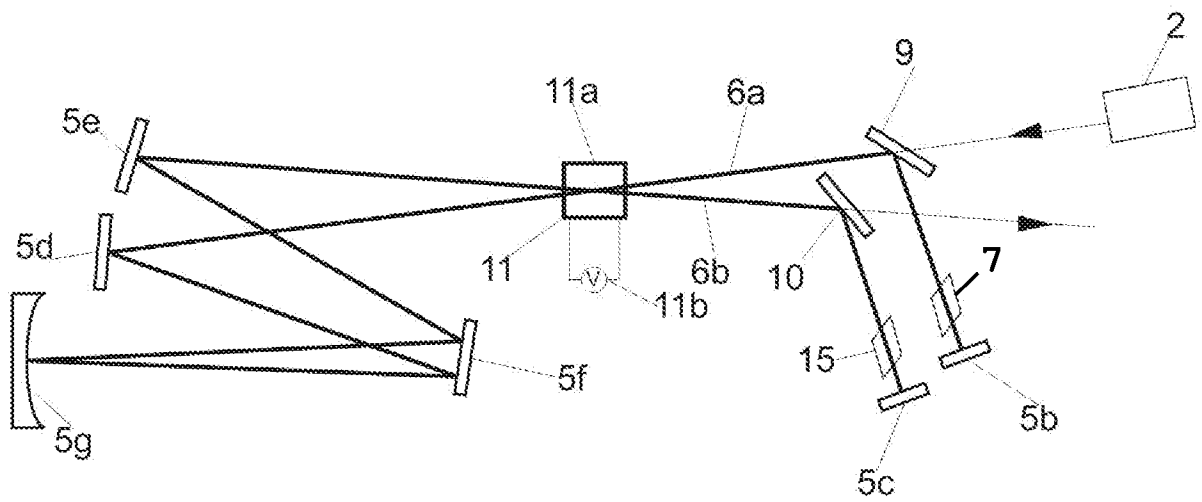


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/AT2017/060317

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01S3/23
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2015/288134 A1 (DANIELIUS ROMUALDAS [LT]) 8 October 2015 (2015-10-08) cited in the application paragraphs [0010] - [0013], [0017] - [0053]; figure 1	1-10
A	----- HREBICEK J ET AL: "25TW Ti:sapphire laser chain at PALS", PROCEEDINGS OF SPIE; DIODE-PUMPED HIGH ENERGY AND HIGH POWER LASERS, vol. 8080, no. 1, 5 May 2011 (2011-05-05), pages 80800U1-80800U7, XP060014814, DOI: 10.1117/12.899051 [retrieved on 1901-01-01] page 2, last paragraph - page 3, paragraph 1; figure 4 ----- -/-	1,10



Further documents are listed in the continuation of Box C.



See patent family annex.

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INTERNATIONAL SEARCH REPORT

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PCT/AT2017/060317

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2011/058249 A1 (ERLANDSON ALVIN CHARLES [US]) 10 March 2011 (2011-03-10) paragraphs [0079] - [0088]; figure 5A -----	1,10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/AT2017/060317

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