Claims

1. A method of aligning a quantum laser beam with a receiver, the method comprising:

generating a quantum laser beam and a first classical, non-quantum, laser beam at a transmitter, the quantum laser beam and the first classical laser beam being substantially aligned in direction;

transmitting the quantum laser beam and the first classical laser beam; and

directing the quantum laser beam and first classical laser beam to a receiver;

measuring the photon reception rate from the quantum laser beam at the receiver, and reporting the photon reception rate to the transmitter;

at the transmitter, making a series of adjustments to the direction of the transmitted quantum laser beam and the first classical laser beam, and monitoring the reported photon reception rate;

wherein, each of the series of adjustments is based, at least in part, on the effect of the preceding adjustment on the reported photon detection rate.

2. The method of claim 1, in which:

if one of the series of adjustments results in a reduction in the reported photon reception rate, reversing that adjustment; and

if one of the series of adjustments results in an increase in the reported photon reception rate, retaining that adjustment.

3. The method of claim 1 or claim 2, in which the series of adjustments begins with a plurality of predetermined adjustments, and the method further comprises:

using the effects of the plurality of predetermined adjustments on the reported photon detection rate to determine a gradient of the photon detection rate relative to the adjusted direction of the transmitted quantum laser beam; and

basing subsequent adjustments, at least in part, on the determined gradient.

4. The method of any preceding claim, in which the directing the quantum laser beam and first classical laser beam to the receiver is carried out using a coarse pointing system, and the series of adjustments to the direction of the transmitted quantum laser beam and the first classical laser beam are carried out using a separate fine pointing system.

5. The method of any preceding claim, and further comprising transmitting a second classical, non-quantum, laser beam from the receiver to the transmitter.

6. A system for aligning a quantum laser beam with a receiver, the system comprising:

a transmitter arranged to:

generate a quantum laser beam and a first classical, non-quantum, laser beam, the quantum laser beam and the first classical laser beam being substantially aligned in direction;

transmit the quantum laser beam and the first classical laser beam; and

direct the quantum laser beam and first classical laser beam to a receiver; and

a receiver arranged to:

measure the photon reception rate from the quantum laser beam;

and report the photon reception rate to the transmitter;

wherein the transmitter is further arranged to make a series of adjustments to the direction of the transmitted quantum laser beam and the first classical laser beam, and monitor the reported photon reception rate; and

wherein, each of the series of adjustments is based, at least in part, on the effect of the preceding adjustment on the reported photon detection rate.

7. The system of claim 6, in which the transmitter is arranged to:

if one of the series of adjustments results in a reduction in the reported photon reception rate, reverse that adjustment; and

if one of the series of adjustments results in an increase in the reported photon reception rate, retain that adjustment.

8. The method of claim 1 or claim 2, or the system of claim 6 or claim 7, in which the series of adjustments are random adjustments.

9. The method of claim 1 or claim 2, or the system of claim 6 or claim 7, in which the series of adjustments follow a predetermined sequence.

10. The method or the system of claim 9, in which the series of adjustments follow a pre-defined scanning motion; and

preferably, in which the pre-defined scanning motion is a conical scan, or a scan across a grid.

11. The system of claim 6 or claim 7, in which the series of adjustments begins with a plurality of predetermined adjustments, and the transmitter is further arranged to:

use the effects of the plurality of predetermined adjustments on the reported photon detection rate to determine a gradient of the photon detection rate relative to the adjusted direction of the transmitted quantum laser beam; and

base subsequent adjustments, at least in part, on the determined gradient.

12. The method of any one of claims 1 or 5 or 8 to 10, or the system of any one of claims 6 to 11, in which each one of the series of adjustments is small; and

preferably, in which each of the adjustments of the series of adjustments is in the range 0.1 to 1 μrad.

13. The system of any one of claims 6 to 12 in which the transmitter comprises a course pointing system arranged to direct the quantum laser beam and first classical laser beam to the receiver, and comprises a separate fine pointing system arranged to carry out the series of adjustments to the direction of the transmitted quantum laser beam and the first classical laser beam.

14. The method of any one of claims 1 to 4, 8 to 10, or 12, or the system of any one of claims 6 to 13, in which the transmitter and the receiver cooperate to align the quantum laser beam with the receiver using a closed loop control method.

15. The system of any one of claims 6 to 14, wherein the receiver is further arranged to transmit a second classical, non-quantum, laser beam to the transmitter.

16. The method of claim 5, or the system of claim 15, in which the second classical laser beam provides a communications link used to report the photon reception rate to the transmitter.

17. The method of any one of claims 1 to 5, 8 to 10, 12, 14 or 16, or the system of any one of claims 6 to 16, in which the transmitter and receiver cooperate to direct the first classical laser beam to the receiver using a first closed loop control method.

18. The method of claim 5 or claim 16, or the system of claim 15 or claim 16, in which the transmitter and receiver cooperate to direct the first classical laser beam to the receiver using a first closed loop control method which uses the second classical laser beam as a beacon.

19. The method of any one of claims 1 to 5, 8 to 10, 12, 14 or 16 to 18, or the system of any one of claims 6 to 18, in which the transmitter and receiver use the first classical laser beam as a communication link from the transmitter to the receiver.

20. The method of claim 5 or claim 16, or the system of claim 15 or claim 16, in which the transmitter and receiver cooperate to direct the second classical laser beam to the transmitter using a closed loop control method; and

preferably, in which the second closed loop control method uses the first classical laser beam as a beacon.

21. The method of any one of claims 1 to 5, 8 to 10, 12, 14 or 16 to 20, or the system of any one of claims 6 to 20, in which the monitoring the reported photon reception rate comprises measuring the photon reception rate for a period of time after each of the series of adjustments.

22. The method, or the system, of claim 21, in which the period of time is a configurable time period, and

preferably, in which the transmitter determines the configurable period of time, and the first classical laser beam is used as a communication link to communicate the configurable time period from the transmitter to the receiver.

23. The method, or the system, of claim 21, in which the period of time is fixed.

24. The method of any one of claims 1 to 5, 8 to 10, 12, 14 or 16 to 23, or the system of any one of claims 6 to 23, in which the quantum laser beam and the first classical laser beam are substantially aligned in direction in parallel; and

preferably, are substantially aligned in direction to be spaced apart in parallel, or to be co-axial.

25. The system of any one of claims 6 to 24, and further comprising:

an optics assembly; and

an optical terminal;

wherein the first classical laser beam and the quantum laser beam are separately generated and provided to the optical assembly, the optical assembly being arranged to align the quantum laser beam to the first classical laser beam and to provide the aligned quantum laser beam and first classical laser beam to the optical terminal; and

wherein the optical terminal is arranged to direct the aligned quantum laser beam and first classical laser beam to the receiver.

26. The method of any one of claims 1 to 5, 8 to 10, 12, 14 or 16 to 24, or the system of any one of claims 6 to 25, in which the quantum laser beam comprises a plurality of quantum photon channels, and the receiver is arranged to measure the photon reception rate by measuring the total photon reception rate across the plurality of channels.

27. A method of aligning a quantum laser beam with a receiver, the method comprising:

generating a quantum laser beam and a first classical, non-quantum, laser beam at a transmitter, the quantum laser beam and the first classical laser beam being substantially aligned in direction;

transmitting the quantum laser beam and the first classical laser beam; and

directing the quantum laser beam and first classical laser beam to a receiver;

making a series of adjustments to the direction of the transmitted quantum laser beam and the first classical laser beam; and

receiving reports of the photon reception rate from the receiver;

wherein, each of the series of adjustments is based, at least in part, on the effect of the preceding adjustment on the reported photon detection rate.

28. A satellite system for aligning a quantum laser beam with a receiver, the system comprising:

laser means arranged to generate a quantum laser beam and a classical, non-quantum, laser beam, the quantum laser beam and the classical laser beam being substantially aligned in direction;

optical means arranged to transmit the quantum laser beam and the first classical laser beam; and

a director arranged to direct the quantum laser beam and first classical laser beam to a receiver; and

communication means arranged to receive reports of a photon reception rate through the quantum laser beam from the receiver;

wherein the system arranged to make a series of adjustments to the direction of the transmitted quantum laser beam and the first classical laser beam, and monitor the received reports of the photon reception rate; and

wherein, each of the series of adjustments is based, at least in part, on the effect of the preceding adjustment on the reported photon detection rate.

29. A computer-readable medium comprising code or computer instructions stored thereon, which when executed by a processor, causes the processor to perform the method according to claim 27.