Technology Offer

Non-Reciprocal Quantum Device with Asymmetric Phase Transport for Wave Control and Energy Conversion

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A novel non-reciprocal quantum device that enables direction-dependent phase transport of electromagnetic or matter waves has been developed. The invention preserves phase coherence in one propagation direction while selectively destroying phase information in the opposite direction through controlled interaction with absorber/emitter elements. This unique functionality enables highly asymmetric wave transmission and provides a new platform for non-reciprocal photonic and electronic components, quantum information processing, interferometric sensing, and novel concepts for thermal energy conversion.

Background

Non-reciprocal devices are indispensable in microwave engineering, photonics and quantum technologies, where they protect sensitive components from back reflections and enable directional signal routing. Conventional isolators and circulators generally rely on magneto-optical materials or complex active control schemes, which may limit miniaturization, integration and compatibility with emerging quantum technologies.

Technology

The present invention introduces a fundamentally different concept based on asymmetric phase transport: waves propagating in the forward direction maintain their phase coherence, whereas waves travelling in the reverse direction undergo controlled phase randomization through quantum-mechanical collapse induced by absorber/emitter elements. The patented quantum device comprises:

- a non-reciprocal transmission structure,
- hybrid couplers, a directional π-phase shifter,
- absorber/emitter elements (e.g. black-body radiators or resistive elements),
- and multiple transmission paths enabling constructive or destructive interference

In the forward direction, partial waves interfere constructively and retain their phase coherence. In the reverse direction, waves are redirected toward absorber/emitter elements, where quantum-mechanical decoherence randomizes their phase before re-emission. This creates pronounced directional asymmetry while conserving energy statistically.

Innovative Aspects

- Direction-dependent preservation or randomization of wave phase
- Non-reciprocal transmission based on asymmetric phase transport
- Quantum-mechanical phase control without relying on magnetic non-reciprocity
- Applicable to electromagnetic waves, electrons and other quantum particles
- Multiple realizations including optical, microwave and electronic implementations
- Compatible with interferometric architectures and integrated quantum circuits
- Broad platform technology with applications extending beyond communication to sensing and energy-related concepts.

Advantages

- High flexibility across optical, microwave and quantum systems
- Potential compatibility with integrated photonic and quantum devices
- Robust interference control through engineered phase transport
- Broad applicability to wave-based information processing
- Platform for future quantum device architectures.

Potential Applications

- Integrated photonic circuits
- Optical isolators and circulators
- Quantum communication
- Quantum information processing
- Quantum memories
- Optical and electronic interferometers
- Precision sensing and metrology
- Chiral photonic systems
- Wave-based signal processing

Patent Information

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