Quantum Keyless Private Communication Versus Quantum Key Distribution for Space Links

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ADDRESSED PROBLEM

Quantum Key distribution for space links is extremely challenging:

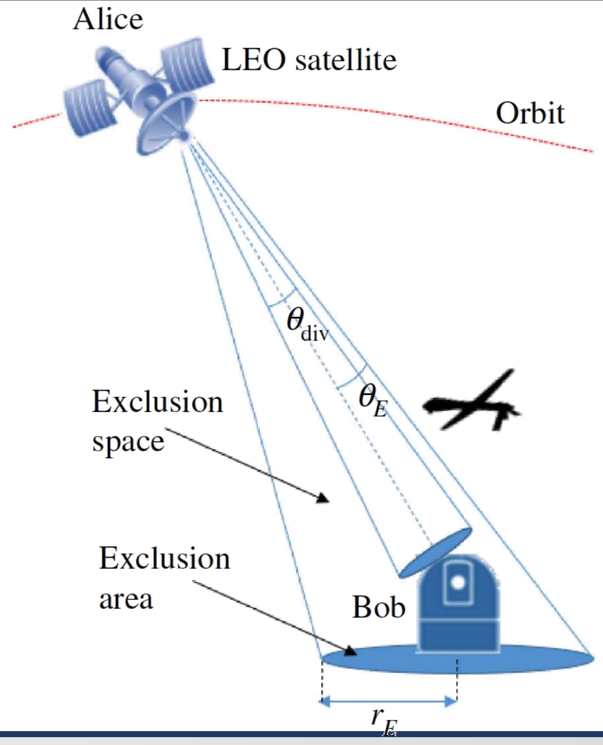
- Achieved key rates are extremely low.
- Daytime operating almost impossible.

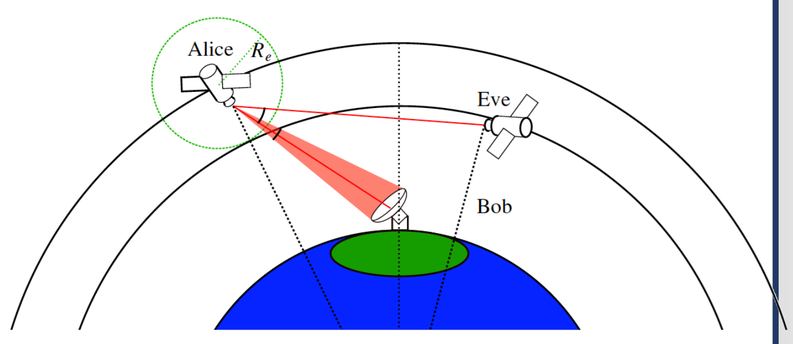
Information theoretical secure

PROPOSED SOLUTION

- Make weak additional assumptions on Eve's power, justified by the laws of physics: Space geometry and orbital mechanics.
- Define and exclusion area for Eve's receiver.
- For detection, Eve is only limited by quantum physics, as in QKD.

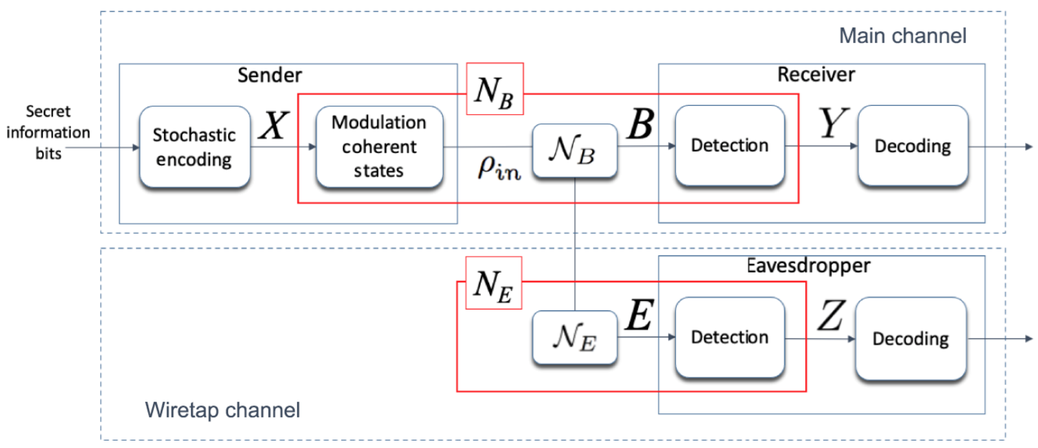
- Design quantum keyless direct secret communication (private communication).

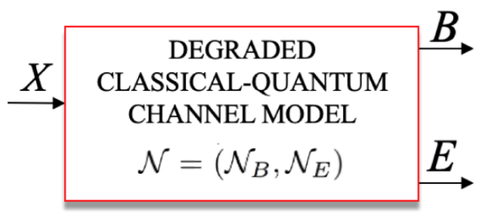




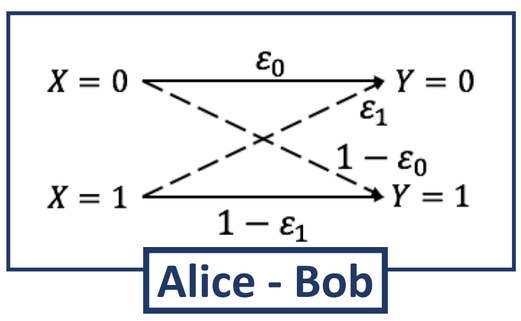
Information theoretical secure

QUANTUM CHANNEL PROBABILISTIC MODELS FOR OOK MODULATION



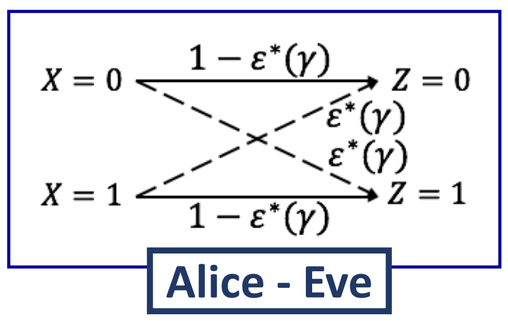


$|\sqrt{\eta}\alpha_1\rangle$



Alice - Bob

$|\sqrt{\eta\gamma}\alpha_1\rangle$



Alice - Eve

The coefficient γ ∈ (0, 1) characterizes the channel degradation. Hence, the efficiency of Eve's channel is γη.

MAIN RESULTS: INFORMATION THEORETICAL SECURE PRIVATE RATES CAPACITIES

Key Analytical Results

$$C_P(\gamma) = \max_q \{I(X;Y) - I(X;Z|\gamma)\}$$

$$C_P(\gamma) = \left[h[\epsilon^*(\gamma)] + h\left(\frac{\epsilon_0+\epsilon_1}{2}\right) - \frac{h(\epsilon_1)+h(\epsilon_0)}{2} - 1\right]_+$$

$$\epsilon_0 = (1-p_{\text{dark}})e^{-\eta_o\Delta}$$

$$\epsilon_1 = (1-p_{\text{dark}})e^{-(\eta\mu+\eta_o\Delta)}$$

$$\epsilon^*(\gamma) = [1-\sqrt{1-4q(1-q)e^{-\eta\gamma\mu}}]/2$$

Key Numerical Results

Configuration	Distance (km)	Channel loss (η_f^B)	QKD (night) $\Delta = 10^{-7}$ Micius	QKD (night) $\Delta = 10^{-7}$ PLOB ($\eta_b = 1$)	Wiretap channel (day) $\Delta = 10^{-4}$ Exclusion radius r_E (m)	Gamma	Private rate (MHz)
LEO	500–1200	22 dB	< 10 kHz	10 MHz	12.5	0.1	700
MEO	10 000	40 dB	···	100 kHz	100	0.1	700
GEO	36 000	52 dB	···	6 kHz	340	0.1	700

For 1GHz clock rate

Reference: Phys. Rev. Applied 16, 014006. (Link to paper)

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