Constellation Optimization for Coherent Optical Channels Distorted by Nonlinear Phase Noise

Christian Häger[1] Alexandre Graell i Amat[1] Alex Alvarado[2] Erik Agrell[1]

[1] Department of Signals and Systems, Chalmers University of Technology, Gothenburg, Sweden,
Fiber Optic Communications Research Center

FORCE

[2] Department of Enginering, University of Cambridge, UK

{christian.haeger, alexandre.graell, agrell}@chalmers.se, alex.alvarado@ieee.org

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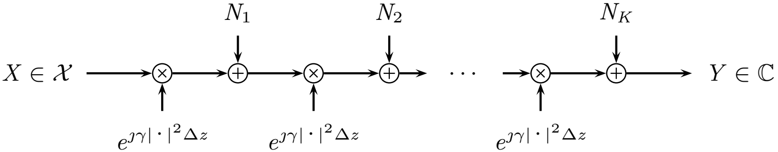
- Theoretical question: How do optimal constellations look like for very strong nonlinearities?

Discrete-Time Channel Model



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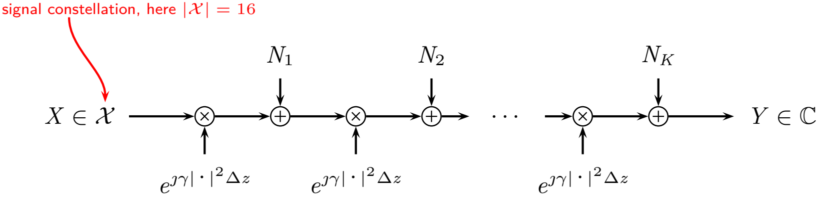

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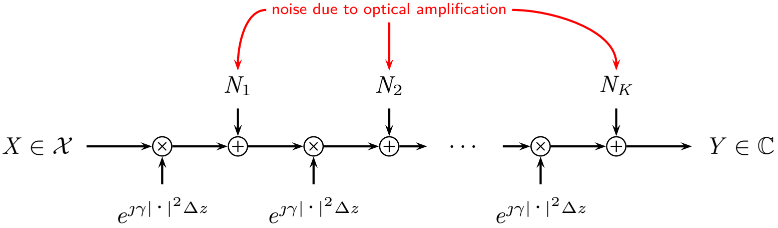

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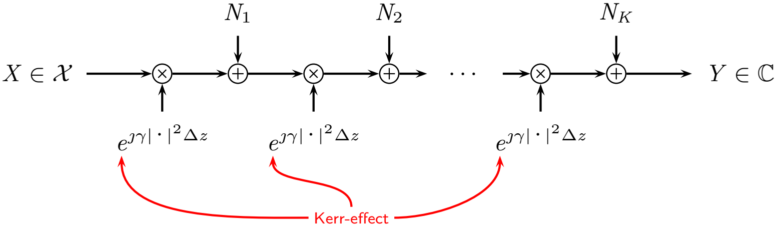

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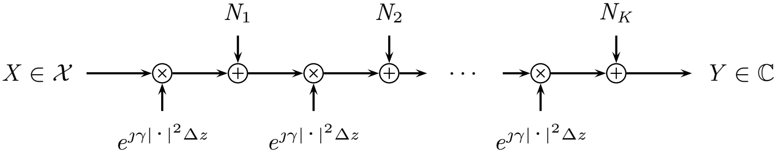

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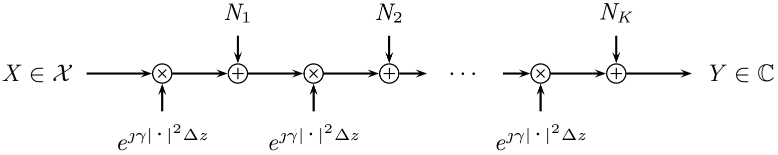

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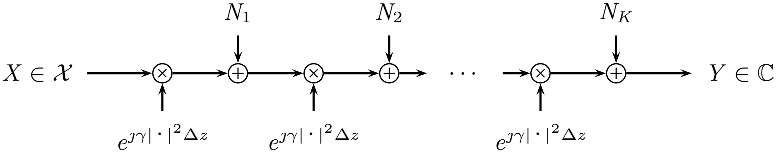

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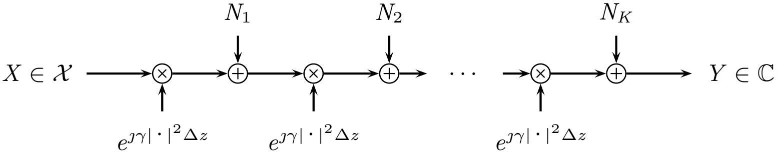

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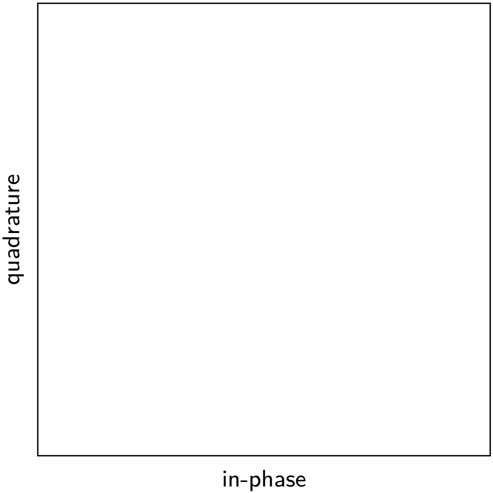
- $L = 5500$ km, other parameters γ, σ^2 taken from [Lau and Kahn, 2007]

Amplitude Phase-Shift Keying (APSK), Example



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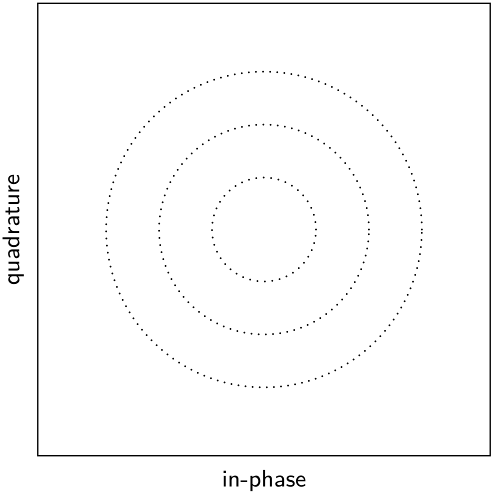

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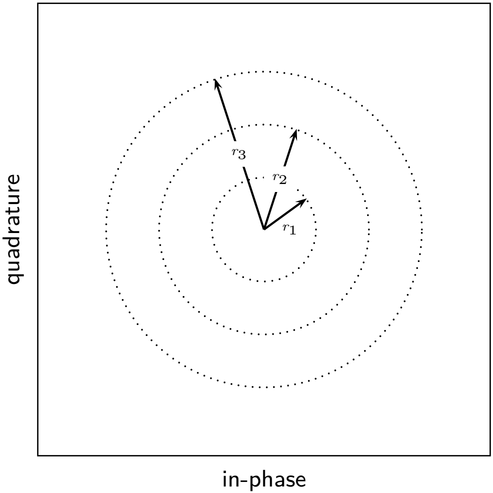

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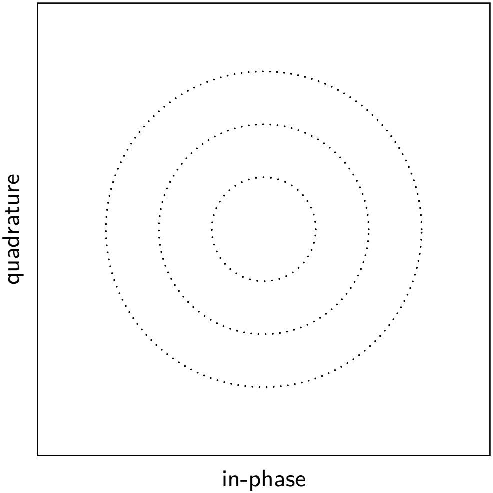

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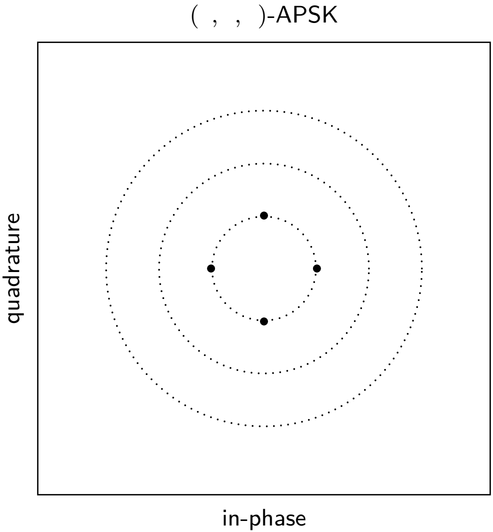

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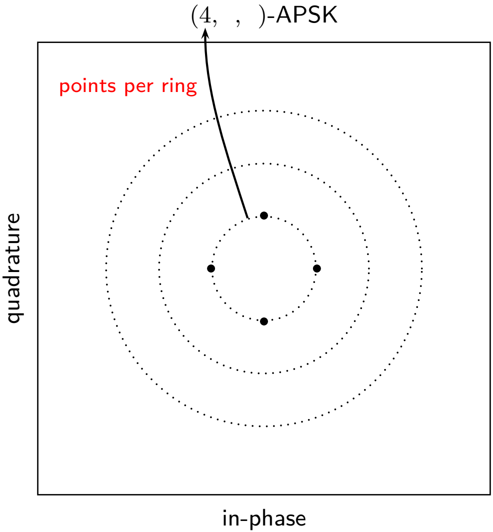

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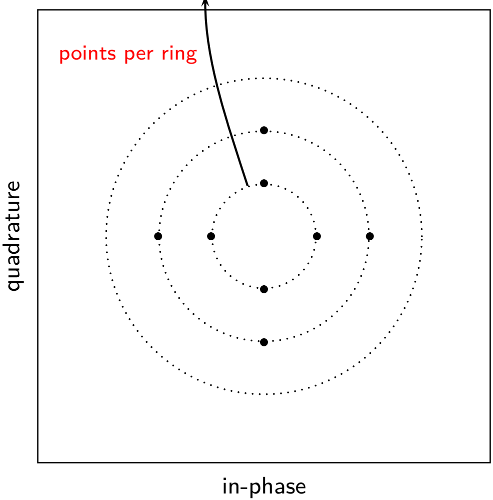

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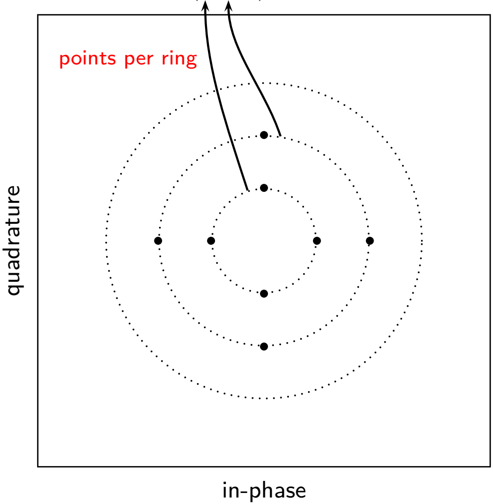

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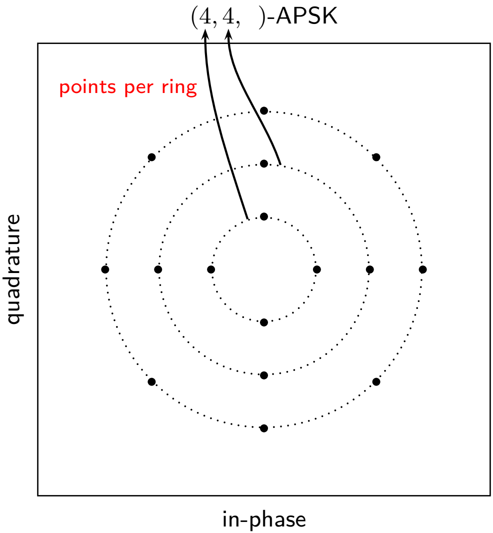

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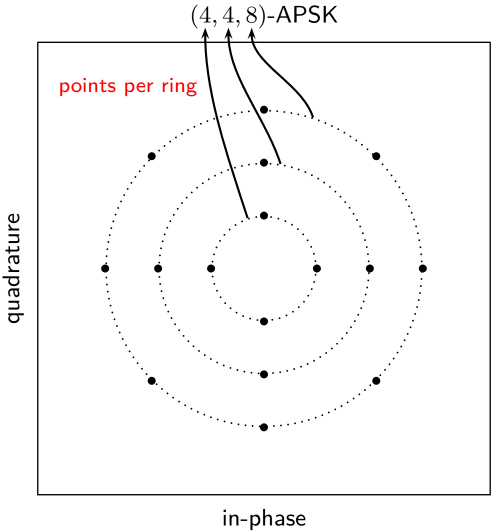

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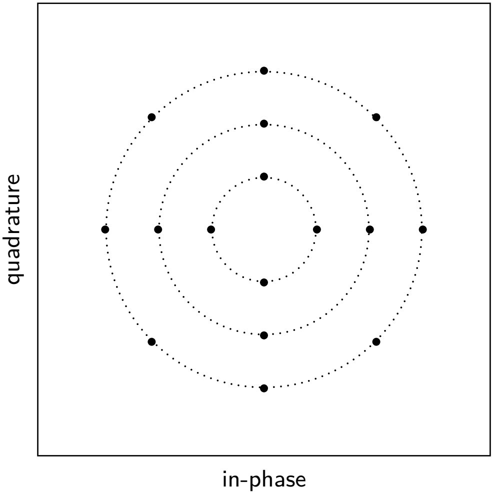

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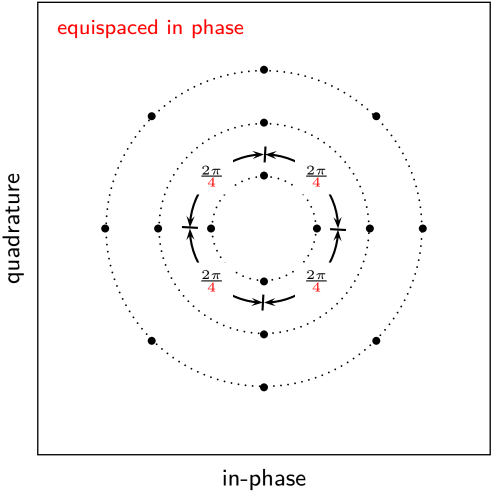

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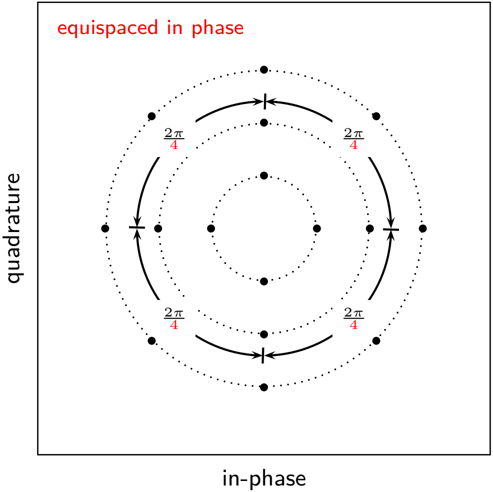

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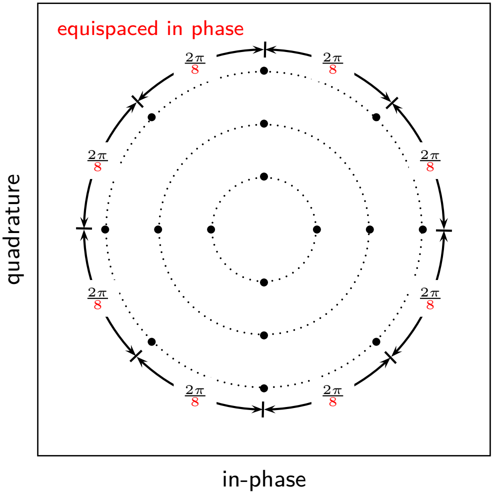

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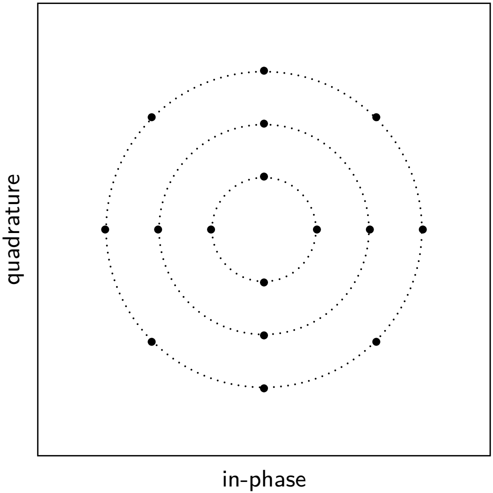

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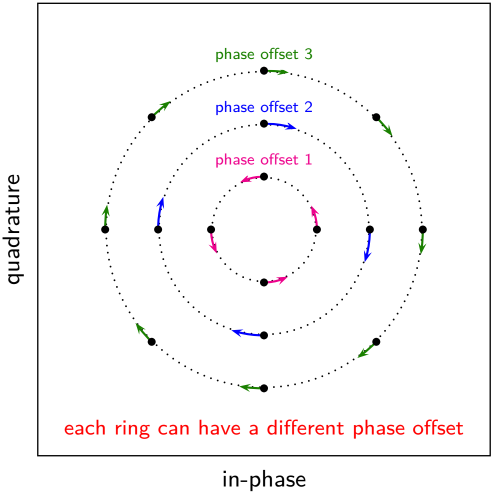

each ring can have a different phase offset

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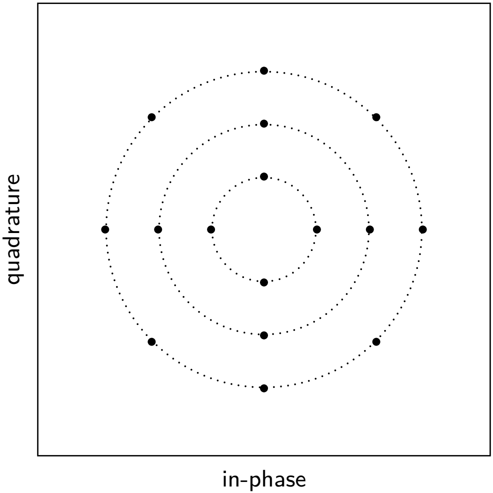

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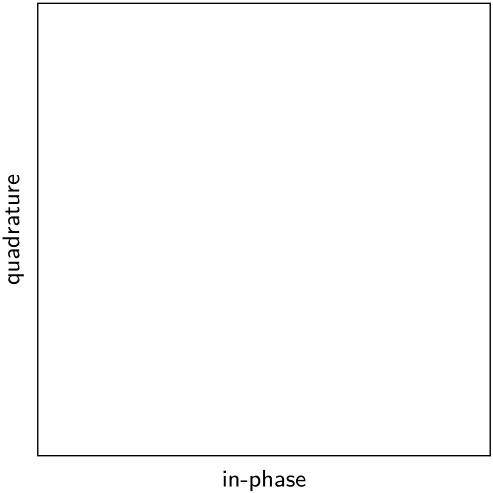

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quadrature

another example

in-phase

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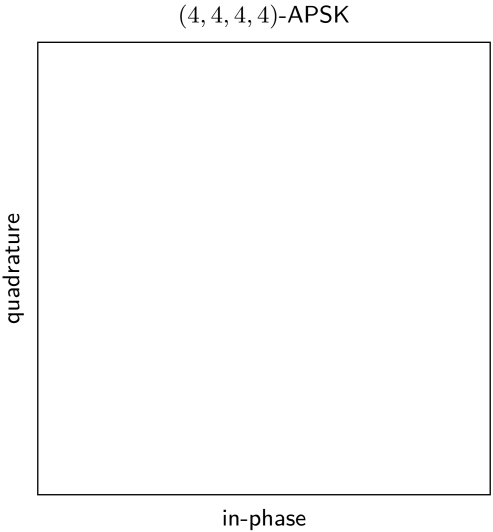

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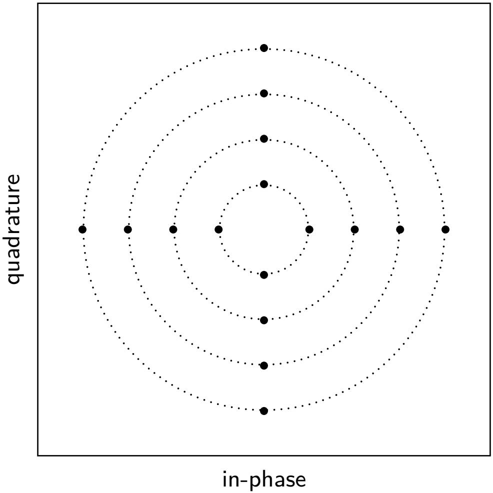

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- See, e.g., [Mecozzi, 1994], [Turitsyn et al., 2003], [Ho, 2005], [Yousefi and Kschischang, 2011]
- Probability density function (PDF) $f_{Y|X=x_i}(y)$ known

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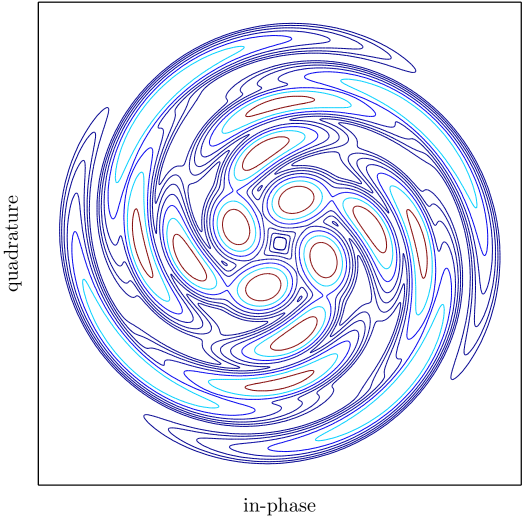

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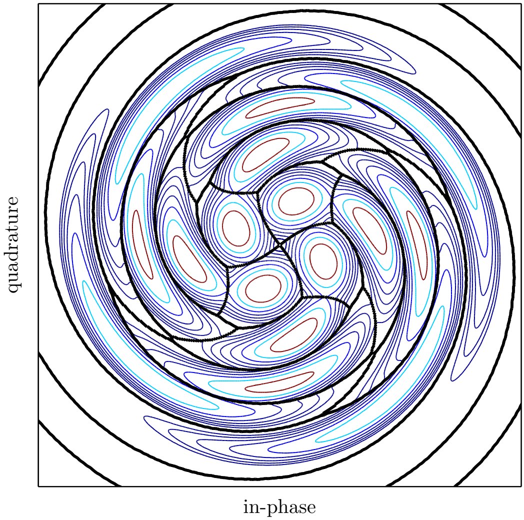

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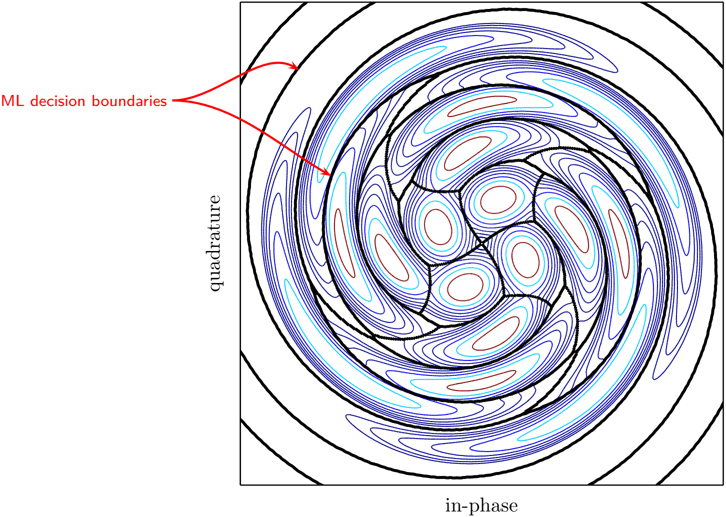

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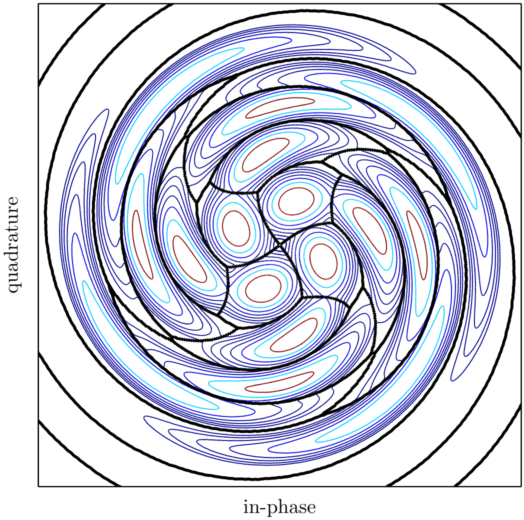

ML detection possible, but not practical.

Nonlinear Phase Postcompensation

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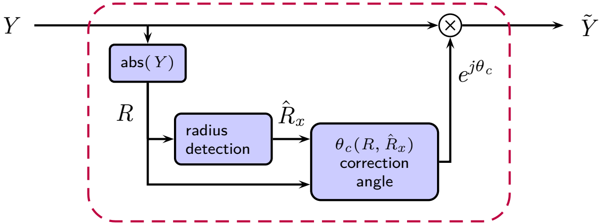

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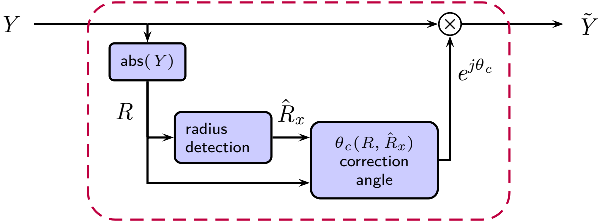

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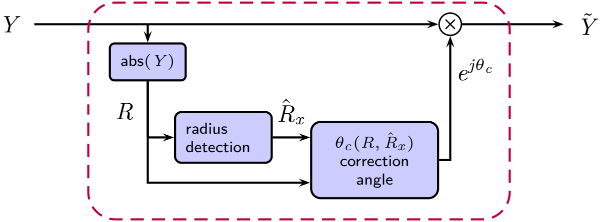

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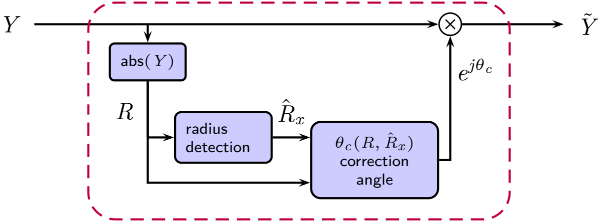

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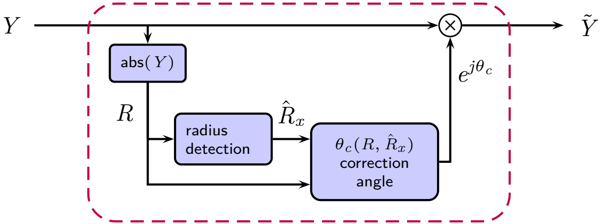

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- However, in principle no loss in optimality due to postcompensation itself (ML detection based on $\tilde{Y}$ still possible)
- Gives insight into why two-stage detection is suboptimal
- Note: the PDF of $\tilde{Y}$ is defined piecewise

PDF of $\tilde{Y}$ for (4,4,4,4)-APSK at $P = -4\,\mathrm{dBm}$

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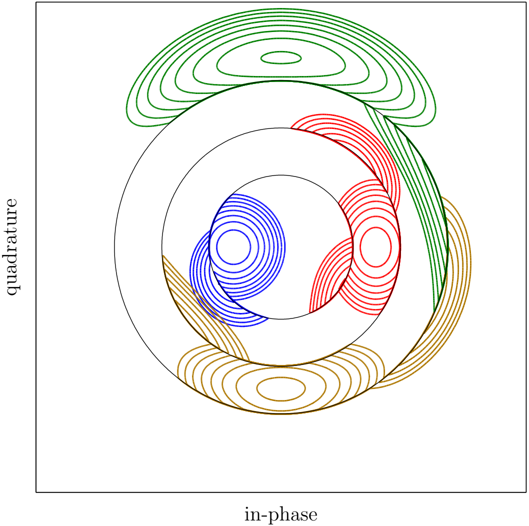

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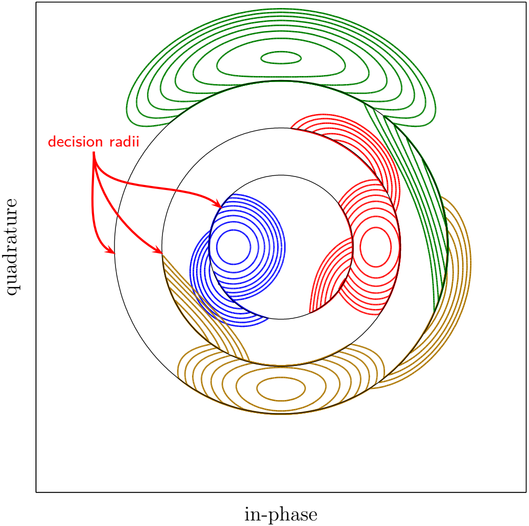

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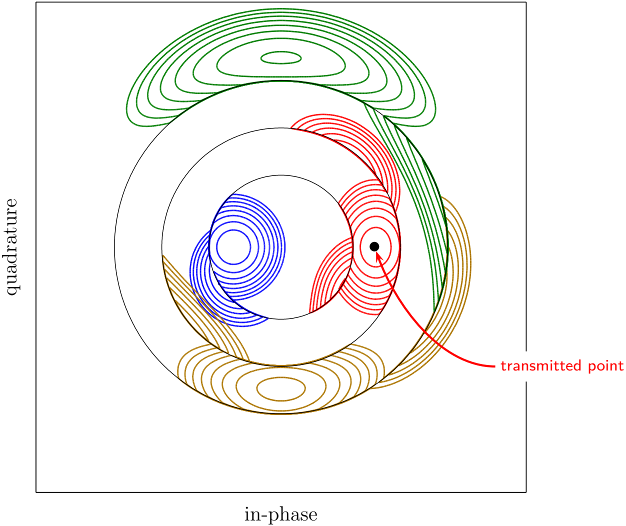

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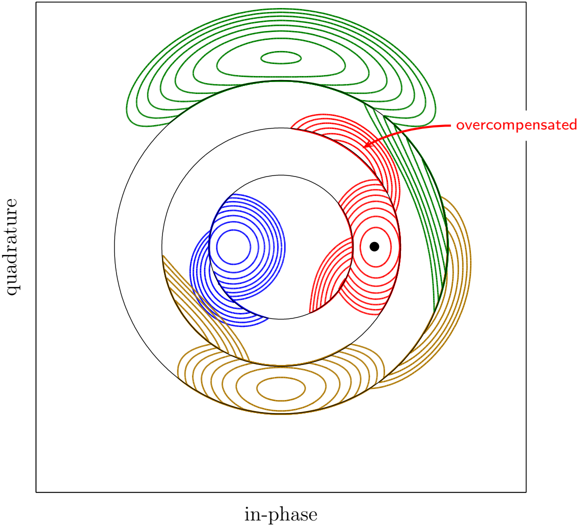

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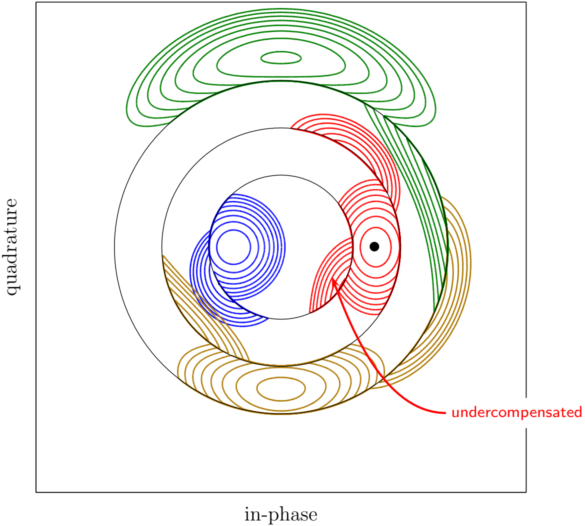

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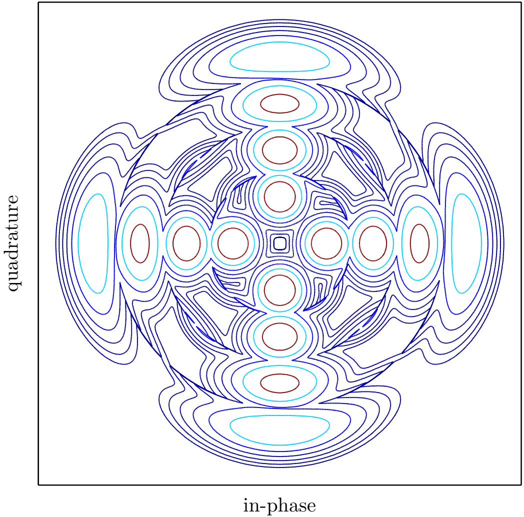

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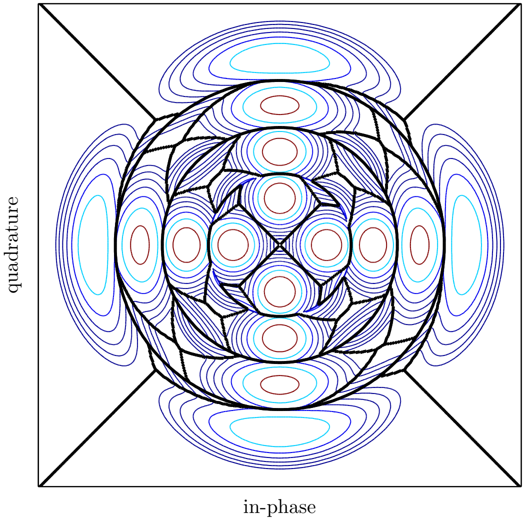

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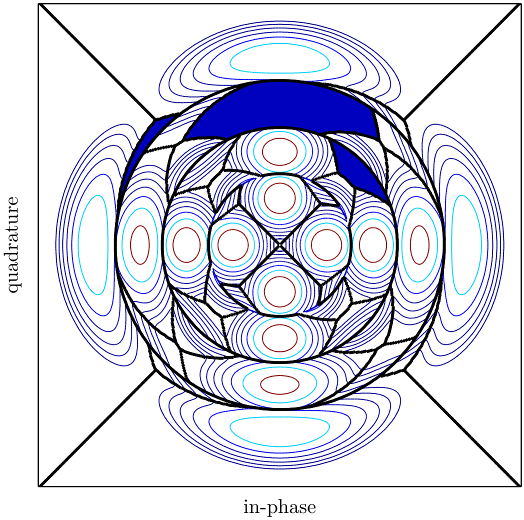

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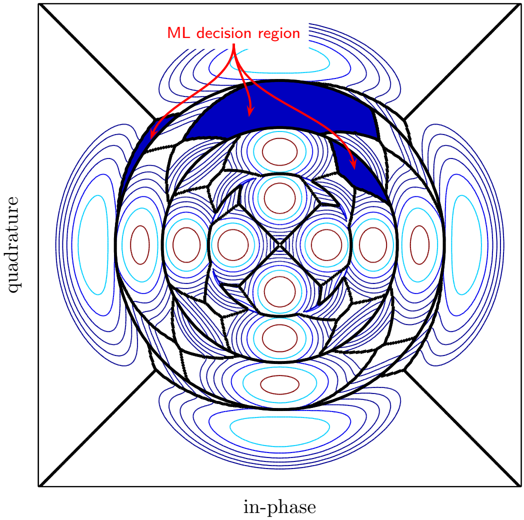

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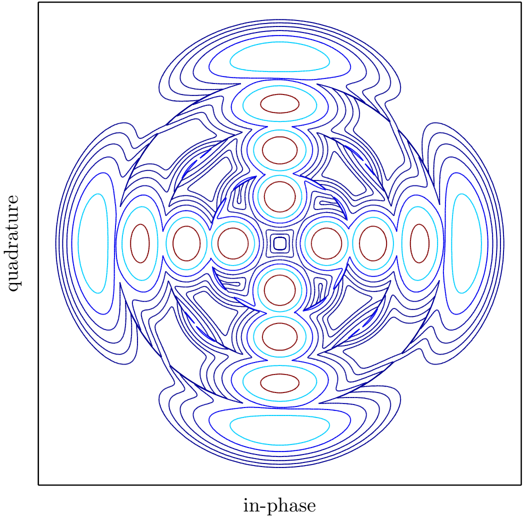

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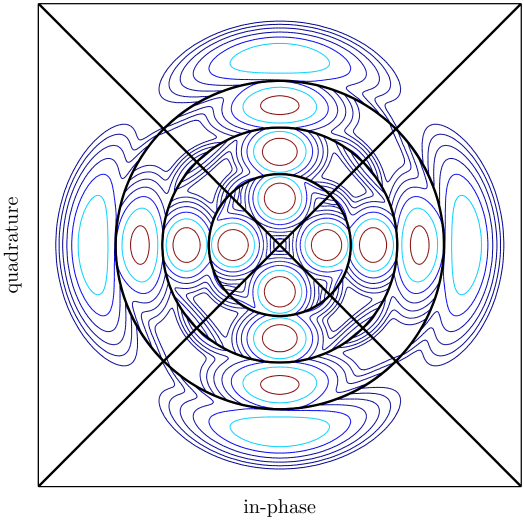

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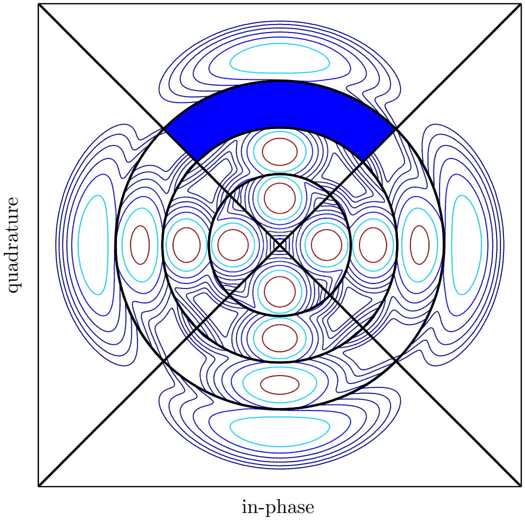

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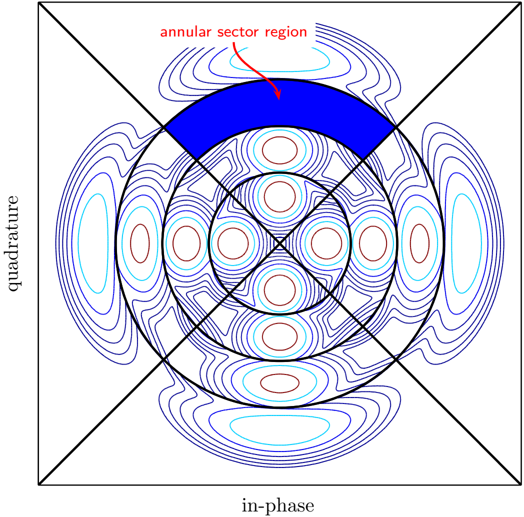

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- What radius distribution?
- What phase offset? Two-stage detection is insensitive to a phase offset.

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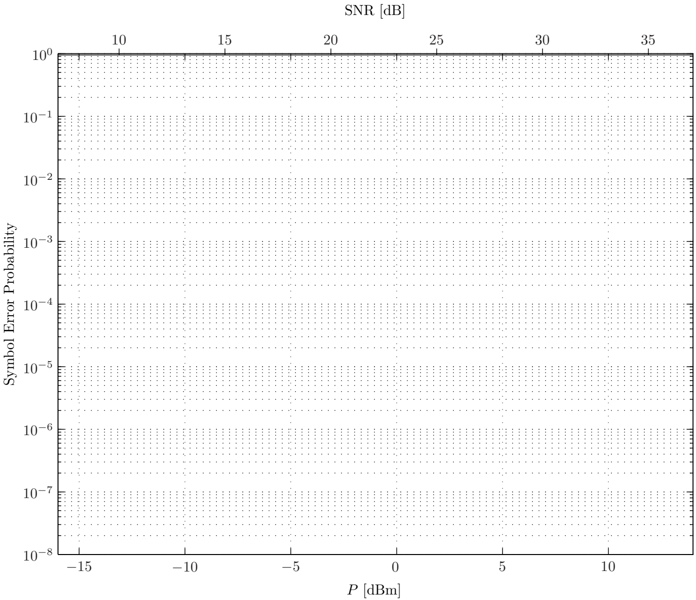

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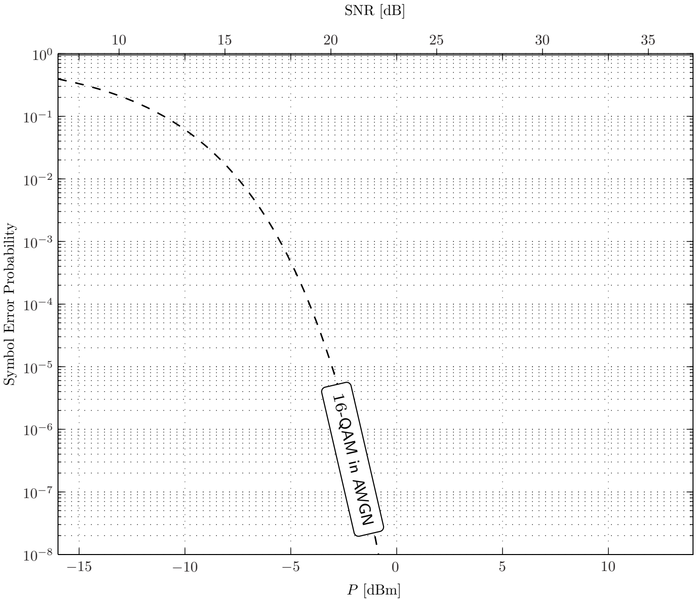

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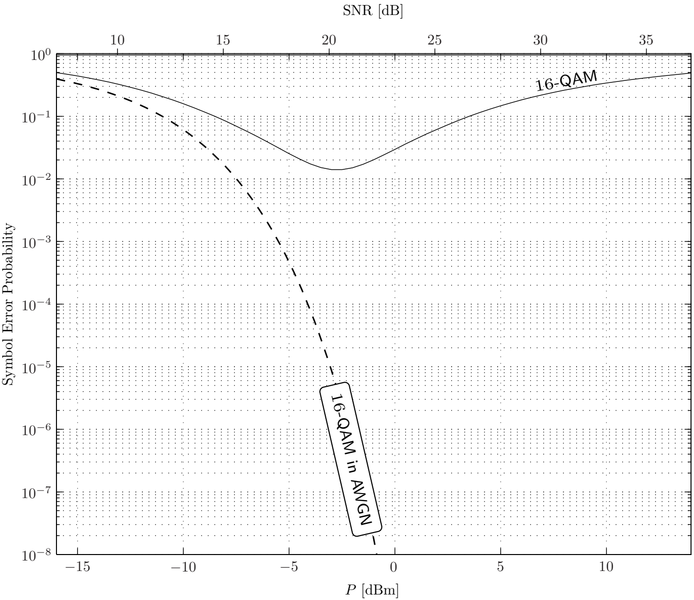

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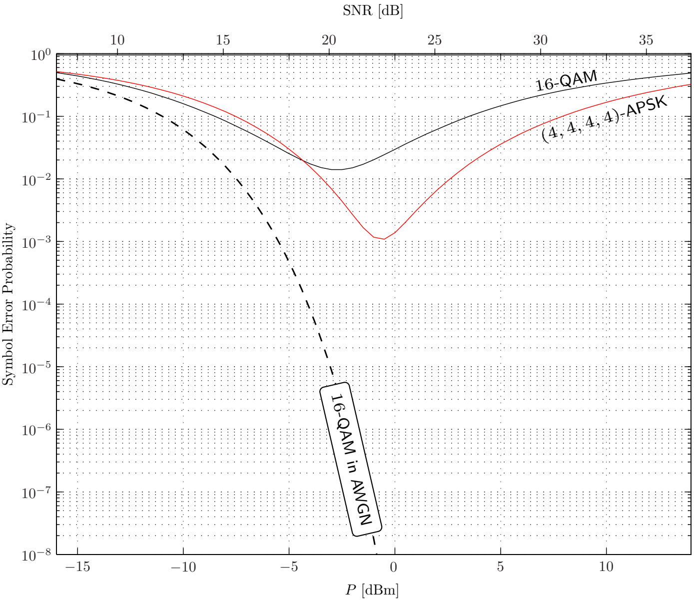

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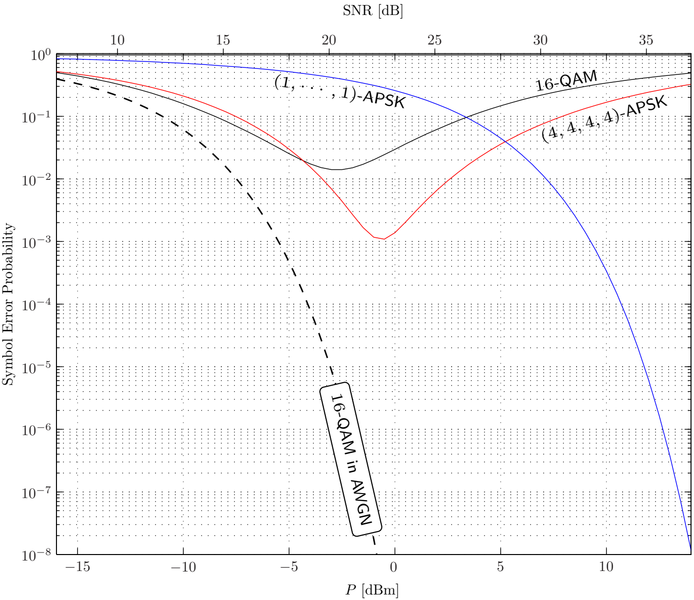

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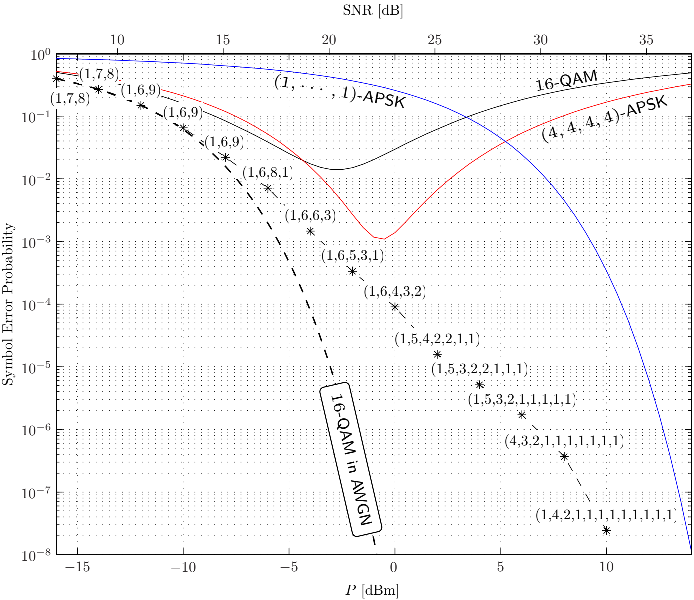
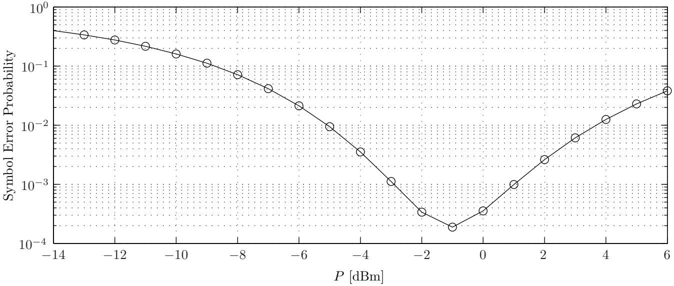
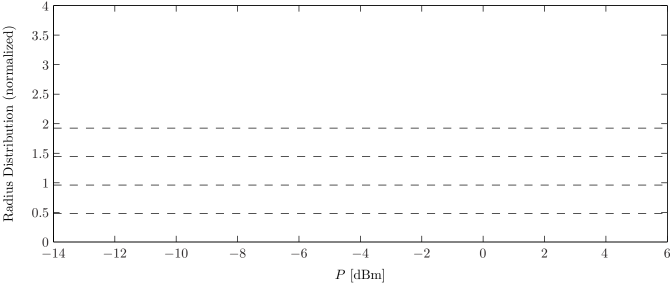


Radius Optimization for (1,6,5,3,1)-APSK





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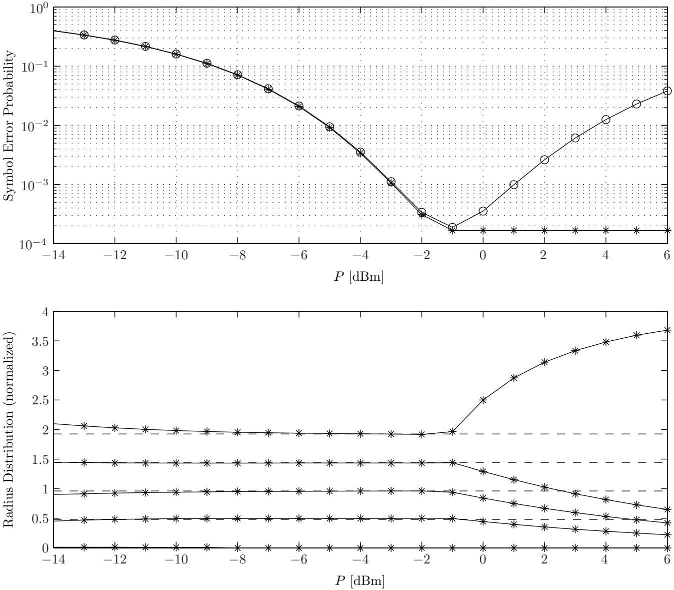

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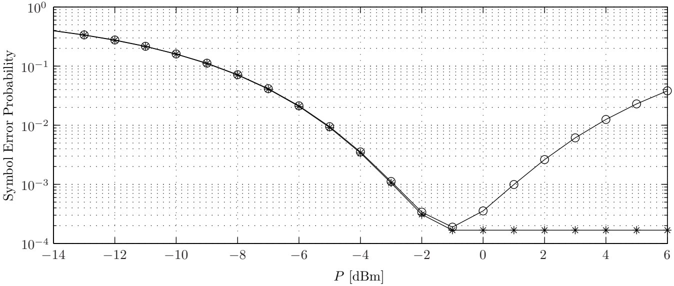

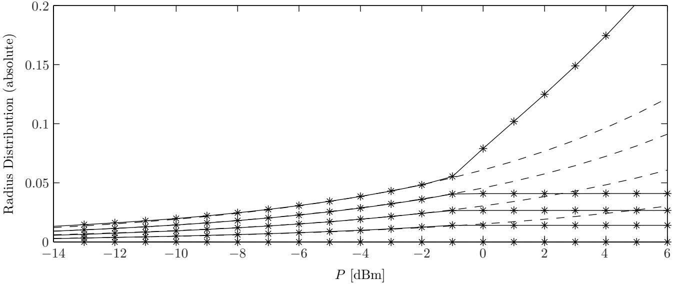

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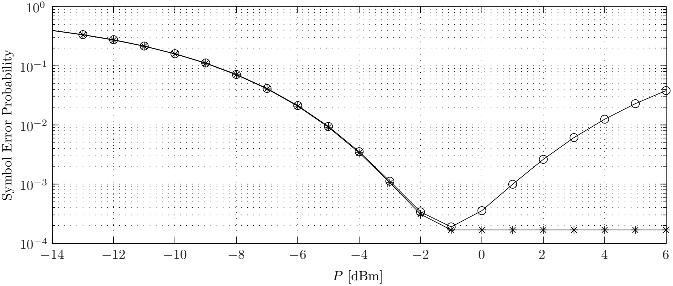

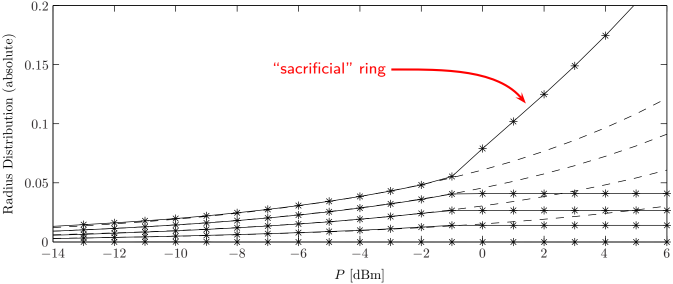

"sacrificial" ring

Conclusions and Future Work

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Thank you!

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Power Dependent Phase Noise

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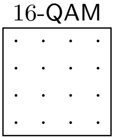

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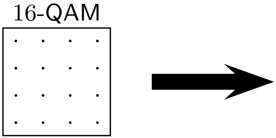

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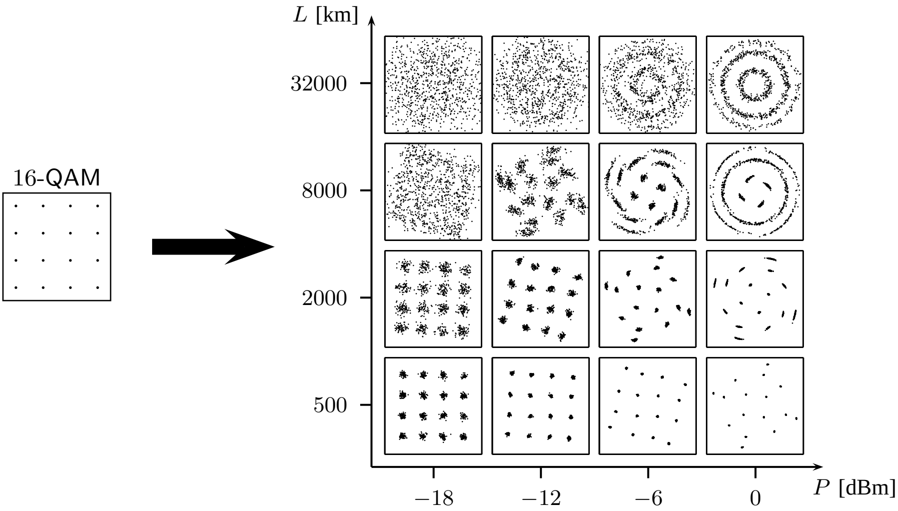

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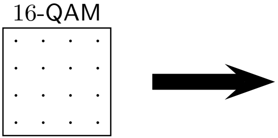

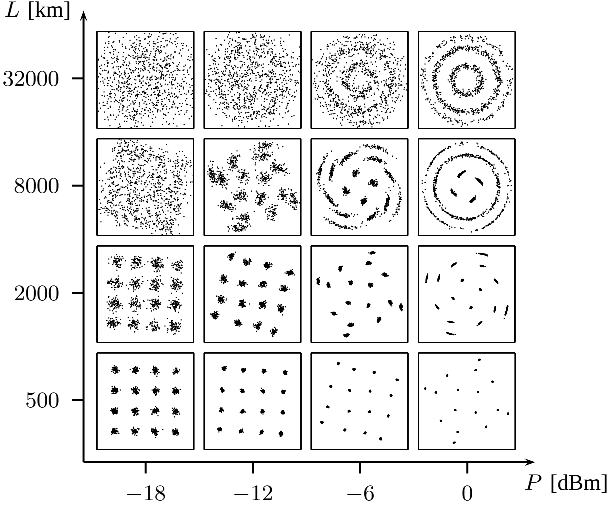

SNR is not sufficient to characterize the channel!