

## Invited Talk

### Superconducting Metamaterials

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I will review experimental studies performed within recently established collaboration between German and Russian laboratories jointly working on various aspects of superconducting and quantum metamaterials. The focus of our experiments is on ultra-low loss electromagnetic medium comprised of networks of compact superconducting resonators. The design flexibility of superconducting thin-film resonators and circuits allows for utilizing small structures down to the nanoscale while maintaining low loss properties, very strong and well-controlled nonlinearity, and frequency tunability in the microwave and mm-wave frequency range [1, 2]. This approach opens up an opportunity to develop superconducting metamaterials with non-trivially tailored electromagnetic properties, which can be functionalized as ultra-compact resonant magnetic dipole arrays [3-6], integrated tunable non-reciprocal circuits [7], left-handed transmission lines [8], active emitter arrays, phase modulators, etc. Another interesting spin-off of superconducting metamaterials is going to be on *quantum* metamaterials comprised of arrays of superconducting qubits [9]. This directing is an emerging new field for fundamental studies in quantum optics using microwaves, opening a possibility to explore collective quantum dynamics of artificially tailored two-level systems under very strong coupling with electromagnetic field.

#### References

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