We have prepared meta-atoms based on radio-frequency superconducting quantum-interference devices (rf SQUIDs) and examined their tunability with dc magnetic field, rf current, and temperature. rf SQUIDs are superconducting split-ring resonators in which the usual capacitance is supplemented with a Josephson junction, which introduces strong nonlinearity in the rf properties. We find excellent agreement between the data and a model that regards the Josephson junction as a resistively and capacitively shunted junction (RCSJ). A magnetic field tunability of 80 THz / Gauss at 12 GHz is observed, a total tunability of 56% is achieved, and a unique electromagnetically induced transparency feature at intermediate excitation powers is demonstrated for the first time. An rf SQUID metamaterial is shown to have qualitatively the same behavior as a single rf SQUID with regard to dc flux and temperature tuning.

For further details and references, see: http://www.cnam.umd.edu/anlage/AnlageSCNIR.htm. See also arXiv:1308.1410v2.

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