Summary: The purpose of this paper is to study spectral properties of a family of Cayley graphs on finite commutative rings. Let $R$ be such a ring and $R^\times$ be its set of units. Let $Q_R = \{u^2 : u \in R^\times\}$ and $T_R = Q_R \cup (-Q_R)$. We define the quadratic unitary Cayley graph of $R$, denoted by $G_R$, to be the Cayley graph on the additive group of $R$ with respect to $T_R$: that is, $G_R$ has vertex set $R$ such that $x, y \in R$ are adjacent if and only if $x - y \in T_R$. It is well known that any finite commutative ring $R$ can be decomposed as $R = R_1 \times R_2 \times \cdots \times R_s$, where each $R_i$ is a local ring with maximal ideal $M_i$. Let $R_0$ be a local ring with maximal ideal $M_0$ such that $|R_0|/|M_0| \equiv 3 \pmod{4}$. We determine the spectra of $G_R$ and $G_{R_0 \times R}$ under the condition that $|R_i|/|M_i| \equiv 1 \pmod{4}$ for $1 \leq i \leq s$. We compute the energies and spectral moments of such quadratic unitary Cayley graphs, and determine when such a graph is hyperenergetic or Ramanujan.

Keywords: spectrum; quadratic unitary Cayley graph; Ramanujan graph; energy of a graph; spectral moment

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