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Energy formula, surface geometry and energy extraction for Kerr-Sen black hole

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We evaluate the surface energy~($calE_s^{\pm}$), rotational energy~($calE_r^{\pm}$) and electromagnetic energy~($calE_{em}^{\pm}$) for a Kerr-Sen black hole~(BH) having the event horizon~($calH^{+}$) and the Cauchy horizon~($calH^{-}$). Interestingly, we find that the sum of these three energies is equal to the mass parameter i.e. $calE_s^{\pm}+calE_r^{\pm}+calE_{em}^{\pm}=calM$. Moreover in terms of the scale parameter ~($\zeta_{\pm}$), the distortion parameter~($\xi_{\pm}$) and a new parameter~($\sigma_{\pm}$) which corresponds to the area~($calA_{\pm}$), the angular momentum ~(J) and the charge parameter~(Q), we find that the mass parameter in a compact form

$calE_s^{\pm}+calE_r^{\pm}+calE_{em}^{\pm}=calM=\frac{\zeta_{\pm}}{2}\sqrt{\frac{1+2\,\sigma_{\pm}^2}{1-\xi_{\pm}^2}}$

which is valid through all the horizons ($calH^{\pm}$). We also compute the equatorial circumference and polar circumference which is a gross measure of the BH surface deformation. It is shown that when the spinning rate of the BH increases, the equatorial circumference increases while the polar circumference decreases. We show that there exist two classes of geometry separated by $\xi_{\pm}=\frac{1}{2}$ {in} Kerr-Sen BH. In the regime $\frac{1}{2}<\xi_{\pm}\leq\frac{1}{\sqrt{2}}$, the Gaussian curvature is negative and there exist \emtwo polar caps on the surface. While for $\xi_{\pm}<\frac{1}{2}$, the Gaussian curvature is positive and the surface will be an oblate deformed sphere. Furthermore, we compute the exact expression of rotational energy that should be extracted from the BH via Penrose process. The maximum value of rotational energy which is extractable should occur for extremal Kerr-Sen BH i.e.

$calE_r^{+}=\left(\frac{\sqrt{2}-1}{2}\right)\sqrt{2calM^2-Q^2}=\left(\sqrt{2}-1\right)\sqrt{\frac{J}{2}}.$

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