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Gravity and dust in 2+1 dimensions

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We study a pressureless dust coupled to gravity with an arbitrary cosmological constant Λ in 2+1 dimensions. This theory has interesting classical solutions and yet remains simple enough to explore the non-perturbative quantization of gravitational degrees of freedom. On the classical side we find the Banados-Teitelboim-Zanelli black hole as a static solution when $\Lambda < 0$, and for $\Lambda = 0$ we find solutions with moving apparent horizons. We are able to quantize a sector of the classical solution space, and look in particular at the horizon operator which measures the location of apparent horizons. Notably, this operator is found to have a non-zero variance on coherent states, implying that apparent horizons are subject to quantum fluctuations.

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