Isolated horizons and the Petrov type D equation

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3-dimensional null surfaces that are Killing horizons to the second order are considered. They are embedded in the 4-dimensional spacetimes that satisfy the vacuum Einstein equations with arbitrary cosmological constant. The Weyl tensor at the horizon is assumed to be of the Petrov type D. Internal geometry of 2-dimensional cross sections of the horizons consists of an induced metric tensor and a rotation 1-form potential. They are a subject to the type D equation [1].

The equation is interesting from both, the mathematical and physical points of view. Mathematically it involves geometry, holomorphic structures and algebraic topology. Physically, the equation knows the secret of the black holes: the only axisymmetric solutions on topological sphere correspond to the the Kerr / Kerr-de Sitter / Kerr-anti-de-Sitter non-extremal black holes or the near horizon limit of the extremal ones [1, 2]. In case of the bifurcated horizons the type D equation implies another spacial symmetry. In this way the axial symmetry may be ensured without the rigidity theorem [4].

We also studied the equation on the closed 2-dimensional surfaces that have genus > 0 and proved that all of them have constant Gauss curvature and zero rotation [3]. Therefore, the type D equation does not allow rotating horizons of topology different than that of the sphere (or its quotient). Consequently, we provide a quasi-local argument for a black hole in 4-dimensional spacetime to have a topologically spherical cross-section. The obtained result completes a new local non-hair theorem.

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[2] D. Dobkowski-Ryłko, J. Lewandowski and T. Pawłowski, *Local version of the no-hair theorem*, Phys. Rev. D **98** (2018), 024008, doi:10.1103/PhysRevD.98.024008 [arXiv:1803.05463 [gr-qc]].

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