

# Extreme Universe

## The 25th COLLOQUIUM

May 13<sup>th</sup> (Mon.) ONLINE

TALK 10:00 - 11:00 (JST)

May 12<sup>th</sup> (Sun.) 20:00 - 21:00 (CDT)

May 13<sup>th</sup> (Mon.) 1:00 - 2:00 (GMT)

TIME for chatting  
11:00 - 12:00 (JST)

Registration required (click [HERE](#))

Extreme Universe, JAPAN



Speaker

Prof. Robert Wald

University of Chicago

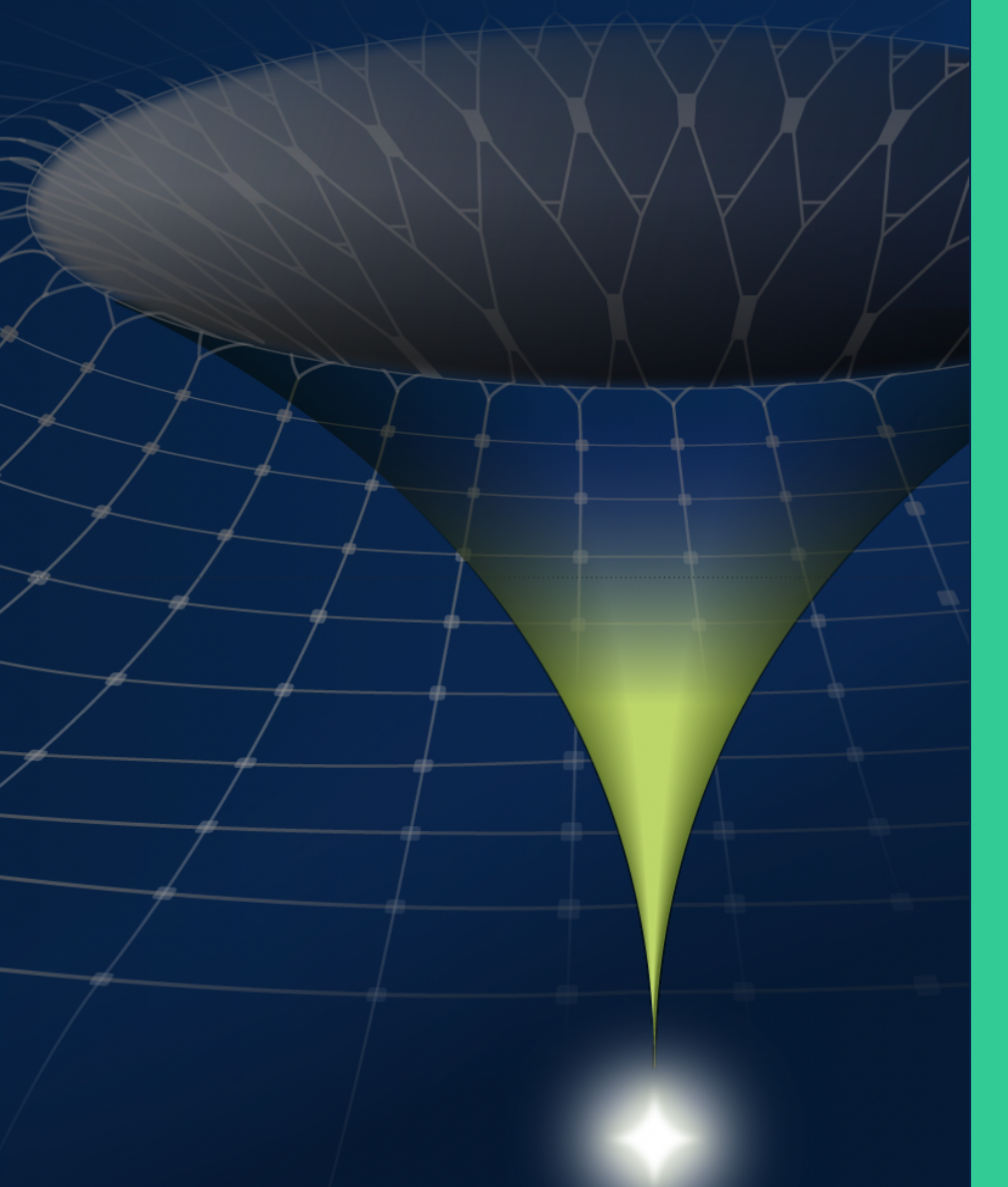
Collaboration

Title **The Entropy of Dynamical Black Holes**

### Abstract

We propose a new formula for the entropy of a dynamical black hole---valid to leading order for perturbations off of a stationary black hole background---in an arbitrary classical diffeomorphism covariant Lagrangian theory of gravity in  $n$  dimensions. In stationary eras, this formula agrees with the usual Noether charge formula, but in nonstationary eras, we obtain a nontrivial correction term. In general relativity, our formula differs from the usual Bekenstein-Hawking formula by a term involving the integral of the expansion of the null generators of the horizon and is equal to  $1/4$  of the area of the apparent horizon to leading order. Our formula for entropy in a general theory of gravity obeys a "local physical process version" of the first law of black hole thermodynamics. For first order perturbations sourced by external matter that satisfies the null energy condition, our entropy obeys the second law of black hole thermodynamics. For vacuum perturbations, the second law is obeyed at leading order if and only if the "modified canonical energy flux" is positive (as is the case in general relativity but presumably would not hold in general theories). We relate our entropy expression to a formula previously proposed independently by Dong and by Wall and we investigate the validity of the generalized second law and its relationship to the quantum null energy condition (QNEC).

2024



MEXT -KAKENHI- Grant-in-Aid for Transformative Research Areas (A)

The Natural Laws of Extreme Universe -A New Paradigm for Spacetime and Matter from Quantum Information-