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*Inverse problems for Einstein's equations and other non-linear hyperbolic equations*

We consider inverse problems for non-linear wave equations, for example, for the equation  $\square_g u + au^2 = f$  on a Lorentzian manifold  $(M, g)$ . We study the question, do the observations of the solutions  $u|_V$  on an open subset  $V \subset M$ , that correspond to sources  $f$  supported in  $V$ , determine the properties of the metric  $g$  in a larger domain  $W \subset M$  containing  $V$ . The domain  $W$  can be the maximal domain to where the information sent from  $V$  can propagate and return back to  $V$ . In addition, we consider inverse problems for the coupled Einstein equations and matter field equations.

To study these problems we define the concept of light observation sets and show that these sets determine the conformal class of the metric.

The results have been done in collaboration with Ali Feizmohammadi, Yaroslav Kurylev, Lauri Oksanen, Gunther Uhlmann, and Yiran Wang.