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Instability of the Far Wake Behind a Wind Turbine

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A stability analysis of the far wake behind a N-bladed wind turbine has been carried out. In conflict with experimental data, previous studies based on stability analysis of point vortices predicted instability at all operating conditions. In the present study the wake description is based on a $(N+1)$-vortex model consisting of N helical tip vortices and a hub vortex, exposed to a constant axial velocity field. An algebraic solution is obtained that provides for an efficient analysis of motion and stability of the $(N+1)$ vortex systems covering a range of helical pitch variations. The stability properties depend basically on vortex strength, helical pitch and vortex core radius. To relate these properties to the operating conditions of a wind turbine, they are approximately expressed in terms of thrust coefficient and tip speed ratio. In accordance with experiments, the far wake is shown to consist of both stable and unstable flow regimes.

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