Abstract Submitted
for the DFD07 Meeting of
The American Physical Society

Structure of a low-momentum elevated jet in cross-flow.[1]
STAVROS TAVOULARIS, ANDREW CAMERON, University of Ottawa, MATTHEW JOHNSON, Carleton University — A complex flow field is generated in a water tunnel by discharging fully developed pipe flow into a uniform cross stream, well above the tunnel's boundary layer. The Reynolds number, based on the outer diameter of the pipe and the free stream velocity, ranged from 400 to 3000 and the ratio R of jet momentum flux to the cross-flow momentum ranged from 0.001 to 0.2, which correspond to the mixing-layer and backward-rolling vortex regimes. Flow visualization has identified the presence of four kinds of vortical structures: a Kármán vortex street, a large standing vortex near the pipe end, shear-ring vortices and tornado-like structures. The shear-ring structures are formed by Kelvin-Helmholtz instability of the nearly-elliptical mixing layer; as the momentum-flux ratio increases, their Strouhal number decreases in a non-linear fashion, with smaller structures merging to larger ones. Tornado-like structures form by stretching of the shear-ring structures; they appear only for $0.02 < R < 0.1$, (mixing-layer regime) and seem to be active vortices. Quantitative studies are in progress to further investigate the nature of the tornado-like structures and the mechanisms of interaction among the different vortex kinds.

[1]Supported by the Natural Sciences and Engineering Research Council of Canada

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Date submitted: 13 Jul 2007 Electronic form version 1.4