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*Gap probability at the hard edge for random matrix ensembles with pole singularities in the potential*

We study the Fredholm determinant of an integrable operator acting on the interval  $(0, s)$  whose kernel is constructed out of the  $\Psi$ -function associated with a hierarchy of higher order analogues to the Painlevé III equation. This Fredholm determinant describes the critical behavior of the eigenvalue gap probability at the hard edge of unitary invariant random matrix ensembles perturbed by poles of order  $k$  in a certain scaling regime. Using the Riemann-Hilbert method, we obtain the large  $s$  asymptotics of the Fredholm determinant. Moreover, we derive a Painlevé type formula of the Fredholm determinant, which is expressed in terms of an explicit integral involving a solution to a coupled Painlevé III system.

This is a joint work with Shuai-Xia Xu and Lun Zhang.