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EDQNM spectral theory for turbulent reacting flows[1] YANJUN XIA, YANG LIU, T. VAITHIANATHAN, LANCE COLLINS, Cornell University
— The eddy damped quasi normal Markovian (EDQNM) spectral theory has been shown to accurately predict energy and scalar spectra under a variety of conditions (e.g., isotropic energy and scalar, anisotropic energy and scalar, homogeneous turbulent shear flow). In this paper, we present an extension of the theory to the case of two initially unmixed scalars undergoing an isothermal bimolecular reaction. Assuming a uniform reaction rate constant, the chemical source term introduces a second-order nonlinearity that can be closed by the EDQNM procedure. If we further assume realizability constraints are satisfied (Ulitsky and Collins; J. Fluid Mech. 412:303, 2000), the model yields spectral distributions for reactants and product fields. Moreover, as molecular diffusion is exact in this representation, the effect of variations in the scalar diffusivities (i.e., differential diffusion) on the mean chemical source term can be calculated. The results show remarkable sensitivity of product-reactant correlations to the molecular diffusivity ratios. We also investigate how these effects scale with the turbulence Reynolds number.

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