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The Maxwell-Bloch system in the sharp-line limit

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We study the characteristic Cauchy problem for the Maxwell-Bloch system that describes the interaction of an optical pulse with an active quantum medium. It is well known that in the sharp-line limit that the atoms in the medium are not Doppler-shifted in frequency, this system can be embedded in the integrable hierarchy of the nonselfadjoint Zakharov-Shabat spectral problem. However, it is also known that there are certain difficulties with formulating and using the inverse-scattering transform based on this spectral problem in the usual way. We construct a Riemann-Hilbert problem that returns the unique causal solution of the Cauchy problem and use it to explain features of solutions such as the stimulated decay by a suitable optical pulse of an unstable medium to its stable state and the spontaneous generation of a dispersive tail of the optical pulse with positive time that ruins absolute integrability that would be needed for the standard inverse-scattering transform to make sense. This tail is related to a specific self-similar solution of the Maxwell-Bloch system that in turn is connected with a concrete special solution of the Painlevé-III equation that has become important in several recent application problems for the focusing nonlinear Schrödinger equation. This is joint work with Sitai Li (Xiamen).

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