$$\sigma_1 = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$$

Riemann–Hilbert Problem 2. *The function* $\Phi_2 : \mathbb{C}\backslash\mathbb{R} \to \mathbb{C}^{1\times 2}$, $\Phi_2(z) = \Phi_2(z; x, t)$ *satisfies*

$$\Phi_2^+(s) = \Phi_2^-(s)\begin{bmatrix} 1-|R_{\mathrm{r}}(s)|^2 & -R_{\mathrm{r}}(-s)\mathrm{e}^{-2\mathrm{i}\lambda(s)x-8\mathrm{i}\varphi(s)t} \\ R_{\mathrm{r}}(s)\mathrm{e}^{2\mathrm{i}\lambda(s)x+8\mathrm{i}\varphi(s)t} & 1 \end{bmatrix}, \quad s^2 > c^2,$$

$$\Phi_2^+(s) = \Phi_2^-(s)\begin{bmatrix} 1 & -R_{\mathrm{r}}(-s)\mathrm{e}^{-2\mathrm{i}\lambda^-(s)x-8\mathrm{i}\varphi^-(s)t} \\ 0 & 1 \end{bmatrix}\sigma_1\begin{bmatrix} 1 & 0 \\ R_{\mathrm{r}}(s)\mathrm{e}^{2\mathrm{i}\lambda^+(s)x+8\mathrm{i}\varphi^+(s)t} & 1 \end{bmatrix}, \quad -c \leq s \leq c,$$

$$\Phi_2^+(s) = \Phi_2^-(s)\begin{bmatrix} 1 & 0 \\ -\frac{C(z_j)}{s-z_j}\mathrm{e}^{2\mathrm{i}\lambda(z_j)x+8\mathrm{i}\varphi(z_j)t} & 1 \end{bmatrix}, \quad s \in \Sigma_j,$$

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$$\Phi_2(z) = \begin{bmatrix} 1 & 1 \end{bmatrix} + O(z^{-1}), \;\; z \to \infty, \quad \varphi(s) = \lambda^3(s) + 3/2c^2\lambda(s),$$

with the symmetry condition

$$\Phi_2(-z) = \Phi_2(z)\sigma_1, \quad z \in \mathbb{C} \setminus \mathbb{R}.$$

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Deformations

We have not implemented all the deformations that are required to compute $q(x,t)$ for all (x,t).

Two deformations allow us to compute the solution for all x and small time, $0 < t < 2$.

More to come, including $t \to \infty$!

All deformations are performed assuming $u_0 \in L^1(\mathbb{R}, \mathrm{e}^{\delta|x|}\mathrm{d}x)$ for some $\delta > 0$.