

**Initial conditions (at first time slice  $t = t_1$ ):**  $\lambda(t = t_1) = 0$  , choose  $B(t = t_1, u)$

**Get the subtracted fields  $\sigma, \dot{\sigma}, \dot{b}$  and  $a$  at first time slice:**

- By solving the 4 radial differential equations. Spectral method. With **Eigen** library (LU decomposition with Full Pivoting ).

**Get  $\lambda$  and  $b$  at the second time slice:**

- Calculate  $\partial_t b$  and  $\partial_t \lambda$  at first time slice.
- Integrate the interpolation of  $\partial_t b$  from  $t = t_1$  to  $t = t_2$  to get  $b(t = t_2, u)$ . Same for  $\lambda$ .

**Get the subtracted fields at the second time slice:**

- By solving the 4 radial differential equations. Spectral method. With **Eigen** library (LU decomposition with Full Pivoting ).

**Get  $\lambda$  and  $b$  at the 3rd time slice:**

- Calculate  $\partial_t b$  and  $\partial_t \lambda$  at second time slice.
- **Interpolation** of  $\partial_t b$  using the values of  $\partial_t b$  at all previous time slices. Same for  $\lambda$ .
- **Integrate** interpolation of  $\partial_t b$  from  $t = t_2$  to  $t = t_3$  to get  $b(t = t_3, u)$ . Same for  $\lambda$ .

**and so on ...**

How to get  **$\lambda$  and  $b$**  at next time slice after a couple of time slices:

- Use **Adams Bashforth** method of 5 steps.

How to get  $\lambda$  and  $b$  at next time slice:

(in more detail)

**Adaptive time stepping:**

- **Define table dts** of 10 elements :

$10^{-4}, 10^{-3.5}, 10^{-3}, 10^{-2.5}, 10^{-2}, 10^{-1.5}, 10^{-1}, 10^{-0.5}, (1 - \text{sum of first part}), 1$

- $dt = 1/2000$
- $t = t + dt * \text{dts}[\text{Min}[\text{Length}[\text{dts}], \text{Length}[\text{timelist}]]];$
- Equidistant time steps starting from 10<sup>th</sup> time slice.

**Store the t\_values** in timelist. ( timelist[[-1]] is the current time.)

How to get  $\lambda$  and  $b$  at next time slice:

**If**

- we are at least at 6<sup>th</sup> time slice
- AND  $(\text{timelist}[\text{[-6]}] - \text{timelist}[\text{[-5]}]) - (\text{timelist}[\text{[-3]}] - \text{timelist}[\text{[-2]}]) < 10^{-12}$

then use **Adams Bashforth** method of **5 steps** (to get  $\lambda$  and  $b$  at next time slice ).

**Else** **integrate a polynomial Interpolation** of  $\partial_t b$  to get  $b$  at the next time slice. Same for  $\lambda$