

The only free variables are  $\delta p$ ,  $\delta ur$ ,  $\delta u\theta$ ,  $\delta u\phi$ ,  $\delta rmd$ , and  $\delta\epsilon$  defined in terms of  $\delta p$ , which is in turn a fn of  $r$ ,  $\theta$  that NDSolve is supposed to find. The variables  $\alpha$ ,  $\beta$ ,  $\nu$ ,  $\omega$ ,  $\epsilon$  and  $p$ , are found from using Interpolation. i.e.  $\alpha = \text{Interpolation}[\text{alpha}]$ . Where alpha is my data. The  $\text{dalphar} = \text{Function}[r, \theta, \text{Evaluate}[D[\alpha, r]]]$ . Similarly for the other d...r or d... $\theta$  terms.  $m = 2$ .  $ut$  is some function of  $r$  and  $\theta$ . Capital omega is just a number.

The only variable that I'm not sure about is  $\sigma$ , and I thought this was throwing errors since I hadn't defined it in any way. So I just tried  $\sigma = 10$ , and it still gave me the same error. I'm also not sure if my BC are right. Could that be causing the issue? I was getting BC errors before but after playing around with the BC those errors went away and I was left with this one.

Once again with hopefully with more clarity, is the command that I've giving mathematica:

```
sol = NDSolve[
{
D[ $\delta ur[r, \theta], r$ ] + D[ $\delta u\theta[r, \theta], \theta$ ] == (ut/ rmd[r,  $\theta$ ] *( $\sigma - m\Omega$ )* $\delta rmd[r, \theta]$ ) -
(2/r + 1/rmd[r,  $\theta$ ]* drmdr[r,  $\theta$ ] + 2dalphar[r,  $\theta$ ] + dbetar[r,  $\theta$ ] + dnur[r,  $\theta$ ])* $\delta ur[r, \theta]$  -
(Cot $\theta$  + 1/rmd[r,  $\theta$ ]*drmd $\theta$ [r,  $\theta$ ] + 2dalpha $\theta$ [r,  $\theta$ ] + dbeta $\theta$ [r,  $\theta$ ] +  $\theta$ [r,  $\theta$ ])* $\delta u\theta[r, \theta]$ 
+ ( $\sigma$ *F[r,  $\theta$ ] - m)* $\delta u\phi[r, \theta]$ ,

D[ $\delta p[r, \theta], r$ ] == (1 /( $\epsilon + p$ ) *D[p[r,  $\theta$ ], r]*( $\delta\epsilon[r, \theta]$  +  $\delta p[r, \theta]$ )) - (( $\epsilon + p$ )*ut)/ Exp [-2
 $\alpha$ )]*( $\sigma - m*\Omega$ )* $\delta ur[r, \theta]$  + (( $\epsilon + p$ )*ut)/ Exp [-2  $\alpha$ )]* (Exp[2  $\beta$ - 2  $\alpha$ ])*  $r^2$ * (Sin $\theta$ )2 * ( $\Omega -$ 
 $\omega$ [r,  $\theta$ ])* D[Log [F[r,  $\theta$ ], r]*  $\delta u\phi[r, \theta]$ ),

D[ $\delta p[r, \theta], \theta$ ] == (1 /( $\epsilon + p$ ) * D[p[r,  $\theta$ ],  $\theta$ ]*( $\delta\epsilon[r, \theta]$  +  $\delta p[r, \theta]$ ) - (( $\epsilon + p$ )* $r^2$  *
ut)/Exp[-2 $\alpha$ )]*( $\sigma - m*\Omega$ )* $\delta u\theta[r, \theta]$  )+ (( $\epsilon + p$ )* $r^2$  * ut)/Exp[-2 $\alpha$ )]*(Exp[2  $\beta$  - 2 $\alpha$ ])*
 $r^2$  * (Sin[ $\theta$ ])2 * ( $\Omega - \omega$ [r,  $\theta$ ])* D[Log[ F[r,  $\theta$ ], r]*  $\delta u\phi[r, \theta]$ ),

(*Boundary Conditions*)
 $\delta\theta[1, \theta] == 0$ ,  $\delta ur[1, \theta] == \delta p[1, \theta] == \delta\theta[r, 1] == \delta ur[r, 1] == \delta p[r, 1] == 0$ , -I* $\gamma$ 1* $\delta p[128,$ 
 $\theta + \delta ur[128, \theta]$ * Evaluate[D[ $\delta p[128, \theta], r]$ ] +  $\delta u\theta[128, \theta]$ *Evaluate[D[ $\delta p[128, \theta], \theta]$ ] == 0,

(*what I'm solving for, and the bounds*)
{ $\delta p$ ,  $\delta ur$ ,  $\delta u\theta$ }, {r, 1, 128}, { $\theta$ , 1, 64}]
```