

## A 26 stage combined order 10 and 11 Runge-Kutta scheme

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### Scheme B.

The order 11 scheme is determined by the parameter values

$$c_7 = \frac{2213}{7686}, c_{13} = \frac{4821}{6055}, c_{17} = \frac{2729}{28575}, c_{18} = \frac{4795}{9144}, c_{19} = \frac{7748}{9605}, c_{20} = \frac{2744}{17139}, c_{21} = \frac{749}{3641}, c_{22} = \frac{3415}{4681}, c_{23} = \frac{5642}{6787}, c_{24} = \frac{4908}{4997}, c_{25} = 1,$$

$$a_{18,17} = -\frac{962}{41393}, a_{19,17} = -\frac{1843}{17387}, a_{19,18} = \frac{17095}{6468}, b_{25} = \frac{771}{12268},$$

$$a_{24,15} = -\frac{1244}{5583}, a_{24,19} = \frac{3749}{44863}, a_{25,15} = -\frac{3207}{34774}, a_{25,19} = -\frac{6637}{7368}, a_{25,20} = -\frac{17075}{4919}.$$

while the order 10 embedded scheme is determined by the weight  $b_{26}^* = \frac{6}{143}$ .

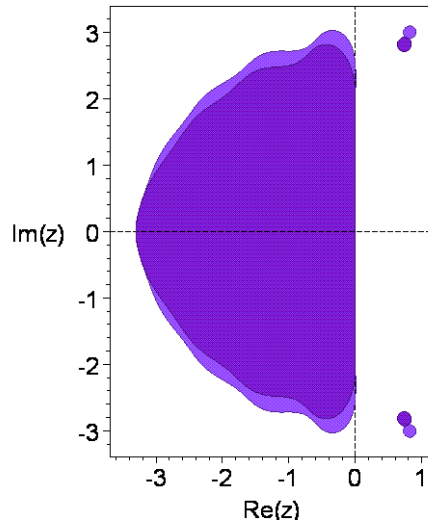
The stage-orders of stages 3 to 26 of the combined scheme are as follows.

stage	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
stage-order	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	7	7	7	7	7	7	7	7	7

The principal error norm of the order 11 scheme is  $0.90151732 \times 10^{(-7)}$  and the principal error norm of the embedded order 10 scheme is  $0.27684033 \times 10^{(-6)}$ .

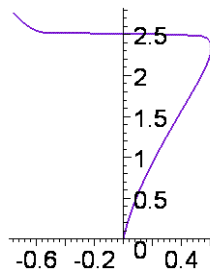
The maximum magnitude of the linking coefficients is 65.498252, while the 2-norm of the linking coefficients is 178.17428.

The stability regions of the two schemes are shown in the following picture in which the stability region of the order 10 scheme is given the darker shade.



The real stability intervals of the order 11 and 10 schemes are respectively  $[-3.30296, 0]$  and  $[-3.30285, 0]$ .

The following picture shows the result of distorting the boundary curve of the stability region of the order 11 scheme horizontally by taking the 11th root of the real part of points along the curve.



The stability region intersects the nonnegative imaginary axis in the interval  $[0, 2.503825 i]$ .

The coefficients correct to 85 digits are as follows.

$c[2]=.2295758765369925126560827414005522868640766572215055609332402467992725538828728284416,$   
 $c[3]=.3443638148054887689841241121008284302961149858322583413998603701989088308243092426624,$   
 $c[4]=.5165457222082331534761861681512426454441724787483875120997905552983632462364638639935,$   
 $c[5]=.1815738283349836241492512796620727005682943185320967874435111484575675892269640025115,$   
 $c[6]=.6357859286958630289346276153590823073051353415974460546050740920341092000890474414857,$   
 $c[7]=.2879260994015092375748113453031485818371064272703616965912047879260994015092375748113,$   
 $c[8]=.4661342315947165993432566141800250998759761801661579710112685264522332446494143576744,$   
 $c[9]=.7646850119302970681422543153906759557027074875843549606453351569550098205232504283037,$   
 $c[10]=.2033910841130835734983337432645779432766018873194395928656855487653884564068565664133,$   
 $c[11]=.5308009909165978530140379851362510322047894302229562345169281585466556564822460776218,$   
 $c[12]=.6874984386739354484781243238035094026885009182774408069425138716016591688269515131373,$   
 $c[13]=.7962014863748967795210569777043765483071841453344343517753922378199834847233691164327,$   
 $c[14]=.1892930080605756422149545910270322525771873166239595690819801842069633456035709887752,$   
 $c[15]=.8797632379050278970432405539500608094000728835931167127244473433312670535613263268011,$   
 $c[16]=.4629211082310759149365293476525038022017694558180142077911759692315928469589444343626,$   
 $c[17]=.9550306211723534558180227471566054243219597550306211723534558180227471566054243219598e-1,$   
 $c[18]=.5243875765529308836395450568678915135608048993875765529308836395450568678915135608049,$   
 $c[19]=.8066631962519521082769390942217595002602811035918792295679333680374804789172306090578,$   
 $c[20]=.1601026897718653363673493202637260050177956706925724954781492502479724604702724779742,$   
 $c[21]=.2057127162867344136226311452897555616588849217248008788794287283713265586377368854710,$   
 $c[22]=.7295449690237128818628498184148686178167058320871608630634479812005981627857295449690,$   
 $c[23]=.8312951230293207602770001473405039045233534698688669515249742154118167084131427729483,$   
 $c[24]=.9821893135881528917350410246147688613167900740444266559935961576946167700620372223334,$   
 $c[25]=1.,$   
 $c[26]=1.,$

$a[2,1]=.2295758765369925126560827414005522868640766572215055609332402467992725538828728284416,$   
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 $a[3,2]=.2582728611041165767380930840756213227220862393741937560498952776491816231182319319968,$   
 $a[4,1]=.1291364305520582883690465420378106613610431196870968780249476388245908115591159659984,$   
 $a[4,2]=0.,$   
 $a[4,3]=.3874092916561748651071396261134319840831293590612906340748429164737724346773478979952,$   
 $a[5,1]=.1130092261504860934412158185507091387538181547299917018334587302183720557891737425481,$   
 $a[5,2]=0.,$   
 $a[5,3]=.1099547836981312725491881183962408478091286349817623488274037651501192580854956206495,$   
 $a[5,4]=-.4139018151363374184115265728487728599465247117965726321735134691092372464770536068604e-1,$   
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 $a[6,4]=.2830078307967382278887960880765022556932541008592359234190146757416421013183930628738,$   
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 $a[7,1]=.6336627856008225390676044813954485741133260214817782032433483923716851879776581223934e-1,$   
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 $a[7,3]=0.,$   
 $a[7,4]=0.,$   
 $a[7,5]=.2230703559034598295194649226187338097950513483903132984010978982273065423955733539315,$   
 $a[7,6]=.1489464937967154148585974544869914630722476731870577865772050461624340315898408640515e-2,$   
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 $a[8,2]=0.,$   
 $a[8,3]=0.,$   
 $a[8,4]=0.,$   
 $a[8,5]=.5760418241677685772917900932492131947126201942793371793191381565584280572266569987479e-1,$   
 $a[8,6]=.1624426193033170166506391215629796607135776644071895242804416447614987151405759535393e-1,$   
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 $a[9,2]=0.,$   
 $a[9,3]=0.,$

a[9,4]=0.,  
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a[9,8]=- .9401727214215340690457804021064266868334862335667919787542674078929474441520403182678e-1,  
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a[10,3]=0.,  
a[10,4]=0.,  
a[10,5]=0.,  
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a[10,7]=.2611176079564830768340458658747229503711047354120245704057991388090054542461486855478,  
a[10,8]=- .2504324538611995055708889530555430160313912103744485644498681967832730796133323392311,  
a[10,9]=- .40553745302467347573044400580198008357844187802863589525228121820415275990549165373931e-1,  
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a[14,5]=0.,  
a[14,6]=0.,  
a[14,7]=0.,  
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a[14,11]=- .2251648869153838972826469679911355122888169954544087302281984093737379355167158368786,

a[14,12]=.6399314343666393872837193160033662605862079963846173247504293593152329521084775320745,  
a[14,13]=.5516413204600861341128678679005160677051593553509521120790594578949602159708188046665,  
a[15,1]=.5565874737935222414728472733115542405907194812320657064606867680195268897621850634742e-1,  
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a[15,14]=.2935701099312602610447891691136529481299077267331988615109247557951863974461647305129,  
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a[18,1]=.608137252048137615208827070181494459893541475023692985876856698599089596148421285973e-1,  
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a[18,12]=-.2569665696058926886902478270532493727810378919788230790627556710942625107464731862502,  
a[18,13]=.1515607925825529219209876342667146315392682685403324133563612030664779409594200677227,  
a[18,14]=.3240543825846064068368733794164415740789863071390430979559478039363842797155062886331,  
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a[18,17]=-.2324064455342690793129273065494165680187471311574420795786727224409924383349841760684e-1,  
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a[19,11]=-.1.535843978195705923740123615414576813652703103148952477282124509630188294656697324036,  
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a[19,14]=.4381469649514387678344129775746267156842408770173873702749594698799311823031240576574,  
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a[19,16]=-.6671186758486333256568599128189436843215047853255936648355673298513489639979415844495,  
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a[19,18]=2.643011750154607297464440321583178726035868893011750154607297464440321583178726035869,  
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a[20,5]=0.,  
a[20,6]=0.,  
a[20,7]=0.,  
a[20,8]=0.,  
a[20,9]=0.,  
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a[20,14]=.1655032253672375026120116516625304868442117639992565778332525360742136902121873218684,  
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a[20,17]=.2492649758493010736581719870382234320315233692134704719694829575354503910262810979769,  
a[20,18]=.8569784961706303274727970451099001224828107740850339504630708513237714123486354367778,  
a[20,19]=.1971754285803505518680226708297792076122817003034620307176377338259216697525832761894,  
a[21,1]=-.1447909869955640525039921726998687504586996678556979471617525381810142287631141268794e-1,  
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a[21,9]=0.,  
a[21,10]=0.,  
a[21,11]=-.4046455772503413698382338735547099093230819937399827323575452172133958583241589682981,  
a[21,12]=.6716177171832775217813132573622724292338207140958635752785103039659263419265996644255,  
a[21,13]=.5846840109336761163382777356461752556815197498345748469771656369015609761268387168829,  
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a[21,16]=1.090872361176570211083713609350572254056517261210122959033561352992898920833121762528,  
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a[21,18]=-.9441629485361175742968662339181085773652174121970116700425711339895748845429122160393,  
a[21,19]=.2178005608693230694809972788246732350417653641537290758997383580364540710581998273527,  
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