pyl 2001/2006
Comparaison des solutions d'Edwards et solution numérique.

Les solutions d' equilibre et d' EDwards

```
In[1]:= Beq = Simplify[DSolve[ { B'[t] == ( (1 - B[t])  - K B[t] ),
            B[0] == 0 } ,
           B[t], t ]][[1]]
```

$$\text{BEd}[t\_] := \frac{1 - e^{-(1+K)\,t}}{1+K} + (.87)\,\hat{}\,(-1)\,(\text{Da Pe}\,\hat{}\,(-1/3))\,\frac{e^{-(1+K)\,t}}{1+K}\left(\frac{e^{-(1+K)\,t}-1}{1+K} - K\,t\right)$$

$$\text{Out[1]= } \left\{B[t] \to \frac{1 - e^{-(1+K)\,t}}{1+K}\right\}$$

■ comparaison DaPe^(1/3) et Pe

```
In[3]:= val = {ka → 193032.2881481269`,
          kd → 0.006932249537744816`, CT → 6.67`*^-7, RT → 930.9014925666793`}
```

```
Out[3]= {ka → 193032., kd → 0.00693225, CT → 6.67 × 10^-7, RT → 930.901}
```

On fait varier le Damkholer

■ comparaison 0

```
In[40]:= valfp = {Pe → P, Da → 0 P^(1/3), K → 1} //. P → 372. //. val
```

```
Out[40]= {Pe → 372., Da → 0, K → 1}
```

temps final

```
In[41]:= tpsf = 2 * 60 / (1 / (ka CT) //. val)

         Ndt = tpsf / .025

         strm = OpenWrite["/Users/pyl/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2/Fi3.IN"]

         WriteString[strm, "N=", IntegerPart[Ndt], "\n",
           "nx=100\nny=100\ndy0=0.01\ndx0=0.01\ndt=0.025\n",
           "Da=", Da //. valfp, "\nPe=", Pe //. valfp,
           "\nK=1\n" ,
           "x1=0.\nx2=1\nT=10000"]
         Close[strm]
```

```
Out[41]= 15.4503
```

```
Out[42]= 618.012
```

```
Out[43]= OutputStream[
          /Users/pyl/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2/Fi3.IN, 20]
```

```
Out[45]= /Users/pyl/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2/Fi3.IN
```

le fichier Fi3.IN est ecrit, il faut le lancer!!!

On lance un terminal, et dans ce terminal
on lance "bia" le programme issu de la compilation des fichiers dans sources

pyl:~/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2 pyl$ ./bia

Resolution des equations dans le BIAcore

->
-->
-->
->

Da=7.191970 Pe=372.000000 K=1.000000
i1 = 0
i2 = 100
t = 15.450000 BM = 0.495000 CM = 0.990000

on trace ensuite.....

la sortie est dans
"BM1.OUT"

mais on a cree en relançant plusieurs fois ces dernières lignes 4 fichiers
(cp BM1.OUT BMD1.OUT etc)
"BMDX.OUT" pour D=X (0,1, 10 100)

In[46]:=

```
lst = ReadList[
   "/Users/pyl/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2/BM1.OUT",
   {Number, Number, Number}];
bc = Table[{lst[[5 * i, 1]], lst[[5 * i, 2]]}, {i, 1, Dimensions[lst][[1]] / 5}];
tmax = 15;

sblzM = NDSolve[{
     B'[t] == (1 - B[t]) ( K B[t]  +  (.807) (Da Pe^(-1 / 3))^(-1)) /
          (1 - B[t] + (.807)  (Da Pe^(-1 / 3))^(-1) )
        - K B[t] ,
     B[0] == 0} //. valfp,
   {B[t]},
   {t, 0, tmax}];


sblz = NDSolve[{
     B'[t] == (1 - B[t]) ( K B[t]  +  (.87) (Da Pe^(-1 / 3))^(-1)) /
          (1 - B[t] + (.87)  (Da Pe^(-1 / 3))^(-1) )
        - K B[t] ,
     B[0] == 0} //. valfp,
   {B[t]},
   {t, 0, tmax}];



calcEq = Show[
  ListPlot[bc(*,PlotJoined→True *), (* PlotStyle→RGBColor[0,0,1],  *)
   DisplayFunction → Identity],

  Plot[ Evaluate[ B[t ] /. sblz], {t, 0, tmax},
   PlotRange → {{0, tmax }, {0, 1}}, (*PlotStyle→RGBColor[1,0,0],*)
   DisplayFunction → Identity],

  Plot[  Evaluate[ B[t ] /. sblzM], {t, 0, tmax},
   PlotRange → {{0, tmax }, {0, 1}},
   PlotStyle → Dashing[{0.025, 0.025}],
   (*PlotStyle→RGBColor[1,1,0],*)
   DisplayFunction → Identity],



  Plot[ Evaluate[ B[t ] /. Beq //. valfp], {t, 0, tmax},
   PlotRange → {{0, tmax }, {0, 1}}, (*PlotStyle→RGBColor[0,1,0],*)
   DisplayFunction → Identity],


  (*Plot[   Evaluate[ BEd[t  ]//.valfp],{t,0,tmax},
    PlotRange→{{0,tmax },{0,1}},PlotStyle→RGBColor[0,0,1],
    DisplayFunction→Identity],*)



  PlotRange → {{ 0, 15}, {0, .5}},
  DisplayFunction → $DisplayFunction,
  Frame → True]
```

Power::infy : Infinite expression $\frac{1}{0}$ encountered. More…

Power::infy : Infinite expression $\frac{1}{0}$ encountered. More…

∞::indet : Indeterminate expression 0 (1 - B[t]) ComplexInfinity encountered. More…

RowReduce::mindet : Input matrix contains an indeterminate entry. More…

RowReduce::mindet : Input matrix contains an indeterminate entry. More…

NDSolve::ntdv : Cannot solve to find an explicit formula for
the derivatives. Consider using the option setting SolveDelayed->True. More…

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NDSolve::ntdv : Cannot solve to find an explicit formula for
the derivatives. Consider using the option setting SolveDelayed->True. More…

ReplaceAll::reps :
{NDSolve[{B′[t] == Indeterminate, B[0] == 0}, {B[t]}, {t, 0, 15}]} is neither a list of replacement
rules nor a valid dispatch table, and so cannot be used for replacing. More…

NDSolve::dsvar : 6.249999999999999`*^-7 cannot be used as a variable. More…

ReplaceAll::reps :
{NDSolve[{B′[6.25×10^{-7}] == Indeterminate, B[0] == 0}, {<<1>>}, {6.25×10^{-7}, 0, 15}]} is neither a list
of replacement rules nor a valid dispatch table, and so cannot be used for replacing. More…

NDSolve::dsvar : 6.249999999999999`*^-7 cannot be used as a variable. More…

ReplaceAll::reps :
{NDSolve[{B′[6.25×10^{-7}] == Indeterminate, B[0] == 0}, {<<1>>}, {6.25×10^{-7}, 0, 15}]} is neither a list
of replacement rules nor a valid dispatch table, and so cannot be used for replacing. More…

General::stop : Further output of ReplaceAll::reps will be suppressed during this calculation. More…

NDSolve::dsvar : 6.249999999999999`*^-7 cannot be used as a variable. More…

General::stop : Further output of NDSolve::dsvar will be suppressed during this calculation. More…

Plot::plnr : B[t] /. NDSolve[{B′[t] == Indeterminate, B[0] == 0}, {B[t]}, {t, 0, 15}]
is not a machine-size real number at t = 6.249999999999999`*^-7. More…

Plot::plnr : B[t] /. NDSolve[{B′[t] == Indeterminate, B[0] == 0}, {B[t]}, {t, 0, 15}]
is not a machine-size real number at t = 0.6085048735937368`. More…

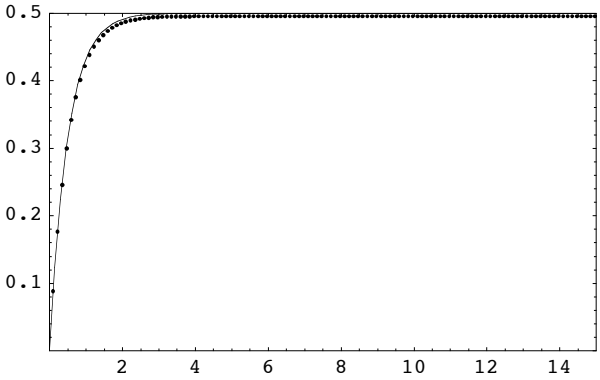
Plot::plnr : B[t] /. NDSolve[{B′[t] == Indeterminate, B[0] == 0}, {B[t]}, {t, 0, 15}]
is not a machine-size real number at t = 1.2721319978906052`. More…

General::stop : Further output of Plot::plnr will be suppressed during this calculation. More…

RowReduce::mindet : Input matrix contains an indeterminate entry. More…

RowReduce::mindet : Input matrix contains an indeterminate entry. More…

NDSolve::ntdv : Cannot solve to find an explicit formula for
the derivatives. Consider using the option setting SolveDelayed->True. More…



Out[51]= - Graphics -

In[52]:= **gD0 = %**

Out[52]= - Graphics -

■ comparaison 1

In[83]:= **valfp = {Pe → *P*, Da → 1 *P*^(1 / 3), *K* → 1} //. *P* → 372. //. val**

Out[83]= {Pe → 372., Da → 7.19197, K → 1}

temps final

In[84]:=
```
tpsf = 2 * 60 / (1 / (ka CT) //. val)

Ndt = tpsf / .025

strm = OpenWrite["/Users/pyl/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2/Fi3.IN"]

WriteString[strm, "N=", IntegerPart[Ndt], "\n",
  "nx=100\nny=100\ndy0=0.01\ndx0=0.01\ndt=0.025\n",
  "Da=", Da //. valfp, "\nPe=", Pe //. valfp,
  "\nK=1\n" ,
  "x1=0.\nx2=1\nT=10000"]
Close[strm]
```

Out[84]= 15.4503

Out[85]= 618.012

Out[86]= OutputStream[
/Users/pyl/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2/Fi3.IN, 27]

Out[88]= /Users/pyl/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2/Fi3.IN

le fichier Fi3.IN est ecrit, il faut le lancer!!!
pyl:~/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2 pyl$ ./bia

Resolution des equations dans le BIAcore

->
-->
-->
->

```
----------------------------------------
 Da=7.191970   Pe=372.000000   K=1.000000
 i1 = 0
 i2 = 100
 t = 15.450000 BM = 0.495000 CM = 0.990000
```

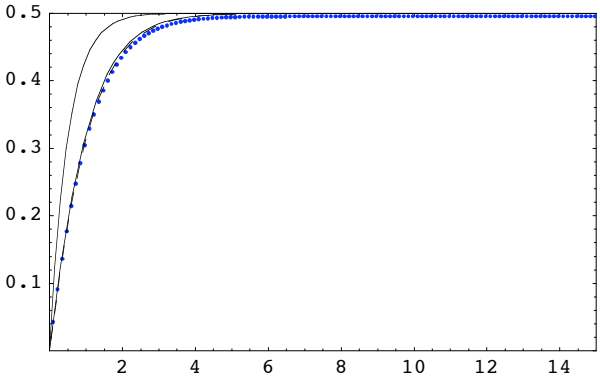
on trace ensuite.....

la sortie est dans
"BM1.OUT"

mais on a cree en relançant plusieurs fois ces dernières lignes 4 fichiers
(cp BM1.OUT BMD1.OUT etc)
"BMDX.OUT" pour D=X (0,1, 10 100)

In[89]:=

```
lst = ReadList[
   "/Users/pyl/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2/BM1.OUT",
   {Number, Number, Number}];
bc = Table[{lst[[5 * i, 1]], lst[[5 * i, 2]]}, {i, 1, Dimensions[lst][[1]] / 5}];
tmax = 15;

sblzM = NDSolve[{
     B'[t] == (1 - B[t]) ( K B[t]  +  (.807) (Da Pe^(-1 / 3))^(-1)) /
          (1 - B[t] + (.807)  (Da Pe^(-1 / 3))^(-1) )
        - K B[t] ,
     B[0] == 0} //. valfp,
   {B[t]},
   {t, 0, tmax}];


sblz = NDSolve[{
     B'[t] == (1 - B[t]) ( K B[t]  +  (.87) (Da Pe^(-1 / 3))^(-1)) /
          (1 - B[t] + (.87)  (Da Pe^(-1 / 3))^(-1) )
        - K B[t] ,
     B[0] == 0} //. valfp,
   {B[t]},
   {t, 0, tmax}];



calcEq = Show[
  ListPlot[bc(*,PlotJoined→True *), PlotStyle → RGBColor[0, 0, 1],
   DisplayFunction → Identity],

  Plot[ Evaluate[ B[t ] /. sblz], {t, 0, tmax},
   PlotRange → {{0, tmax }, {0, 1}}, (*PlotStyle→RGBColor[1,0,0],*)
   DisplayFunction → Identity],

  Plot[  Evaluate[ B[t ] /. sblzM], {t, 0, tmax},
   PlotRange → {{0, tmax }, {0, 1}},
   PlotStyle → Dashing[{0.025, 0.025}],
   (*PlotStyle→RGBColor[1,1,0],*)
   DisplayFunction → Identity],



  Plot[ Evaluate[ B[t ] /. Beq //. valfp], {t, 0, tmax},
   PlotRange → {{0, tmax }, {0, 1}}, (*PlotStyle→RGBColor[0,1,0],*)
   DisplayFunction → Identity],


  (*Plot[   Evaluate[ BEd[t  ]//.valfp],{t,0,tmax},
    PlotRange→{{0,tmax },{0,1}},PlotStyle→RGBColor[0,0,1],
    DisplayFunction→Identity],*)



  PlotRange → {{ 0, 15}, {0, .5}},
  DisplayFunction → $DisplayFunction,
  Frame → True]
```

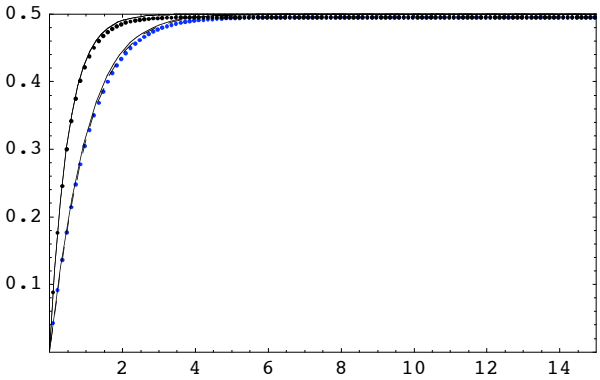


Out[94]= - Graphics -

In[95]:= **gD1 = %**

Out[95]= - Graphics -

In[96]:= **Show[gD1, gD0]**



Out[96]= - Graphics -

■ comparaison 10

In[97]:= **valfp = {Pe → *P*, Da → 10 *P*^(1/3), *K* → 1} //. *P* → 372. //. val**

Out[97]= {Pe → 372., Da → 71.9197, K → 1}

temps final

```
In[98]:= tpsf = 2 * 60 / (1 / (ka CT) //. val)

         Ndt = tpsf / .025

         strm = OpenWrite["/Users/pyl/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2/Fi3.IN"]

         WriteString[strm, "N=", IntegerPart[Ndt], "\n",
           "nx=100\nny=100\ndy0=0.01\ndx0=0.01\ndt=0.025\n",
           "Da=", Da //. valfp, "\nPe=", Pe //. valfp,
           "\nK=1\n" ,
           "x1=0.\nx2=1\nT=10000"]
         Close[strm]

Out[98]= 15.4503

Out[99]= 618.012

Out[100]=
        OutputStream[
         /Users/pyl/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2/Fi3.IN, 29]

Out[102]=
        /Users/pyl/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2/Fi3.IN
```

le fichier Fi3.IN est ecrit, il faut le lancer!!!
pyl:~/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2 pyl$ ./bia

Resolution des equations dans le BIAcore

->
-->
-->
->

Da=7.191970 Pe=372.000000 K=1.000000
i1 = 0
i2 = 100
t = 15.450000 BM = 0.495000 CM = 0.990000

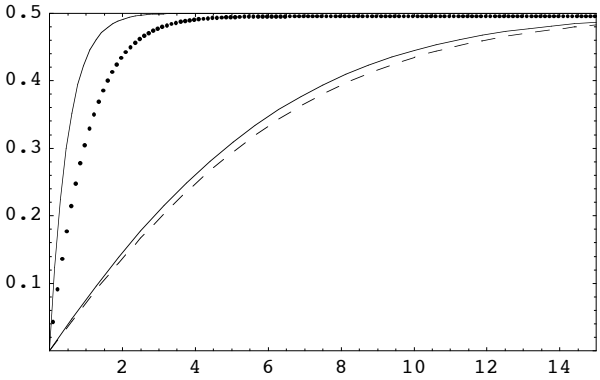
on trace ensuite.....

la sortie est dans
"BM1.OUT"

mais on a cree en relançant plusieurs fois ces dernières lignes 4 fichiers
(cp BM1.OUT BMD1.OUT etc)
"BMDX.OUT" pour D=X (0,1, 10 100)

In[103]:=

```
lst = ReadList[
   "/Users/pyl/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2/BM1.OUT",
   {Number, Number, Number}];
bc = Table[{lst[[5 * i, 1]], lst[[5 * i, 2]]}, {i, 1, Dimensions[lst][[1]] / 5}];
tmax = 15;

sblzM = NDSolve[{
     B'[t] == (1 - B[t]) (K B[t] + (.807) (Da Pe^(-1 / 3))^(-1)) /
          (1 - B[t] + (.807) (Da Pe^(-1 / 3))^(-1) )
        - K B[t] ,
     B[0] == 0} //. valfp,
   {B[t]},
   {t, 0, tmax}];


sblz = NDSolve[{
     B'[t] == (1 - B[t]) (K B[t] + (.87) (Da Pe^(-1 / 3))^(-1)) /
          (1 - B[t] + (.87) (Da Pe^(-1 / 3))^(-1) )
        - K B[t] ,
     B[0] == 0} //. valfp,
   {B[t]},
   {t, 0, tmax}];



calcEq = Show[
  ListPlot[bc(*,PlotJoined→True *), (* PlotStyle→RGBColor[0,0,1],  *)
   DisplayFunction → Identity],

  Plot[ Evaluate[ B[t ] /. sblz], {t, 0, tmax},
   PlotRange → {{0, tmax }, {0, 1}}, (*PlotStyle→RGBColor[1,0,0],*)
   DisplayFunction → Identity],

  Plot[  Evaluate[ B[t ] /. sblzM], {t, 0, tmax},
   PlotRange → {{0, tmax }, {0, 1}},
   PlotStyle → Dashing[{0.025, 0.025}],
   (*PlotStyle→RGBColor[1,1,0],*)
   DisplayFunction → Identity],



  Plot[ Evaluate[ B[t ] /. Beq //. valfp], {t, 0, tmax},
   PlotRange → {{0, tmax }, {0, 1}}, (*PlotStyle→RGBColor[0,1,0],*)
   DisplayFunction → Identity],


  (*Plot[   Evaluate[ BEd[t  ]//.valfp],{t,0,tmax},
    PlotRange→{{0,tmax },{0,1}},PlotStyle→RGBColor[0,0,1],
    DisplayFunction→Identity],*)



  PlotRange → {{ 0, 15}, {0, .5}},
  DisplayFunction → $DisplayFunction,
  Frame → True]
```



Out[108]=

- Graphics -

In[109]:=

gD10 = %

Out[109]=

- Graphics -

■ comparaison 100

In[110]:=

valfp = {Pe → *P*, Da → 100 *P*^(1 / 3), *K* → 1} //. *P* → 372. //. val

Out[110]=

{Pe → 372., Da → 719.197, K → 1}

temps final

In[111]:=

```
tpsf = 2 * 60 / (1 / (ka CT) //. val)

Ndt = tpsf / .025

strm = OpenWrite["/Users/pyl/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2/Fi3.IN"]

WriteString[strm, "N=", IntegerPart[Ndt], "\n",
  "nx=100\nny=100\ndy0=0.01\ndx0=0.01\ndt=0.025\n",
  "Da=", Da //. valfp, "\nPe=", Pe //. valfp,
  "\nK=1\n" ,
  "x1=0.\nx2=1\nT=10000"]
Close[strm]
```

Out[111]=

15.4503

Out[112]=

618.012

Out[113]=

OutputStream[
 /Users/pyl/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2/Fi3.IN, 31]

Out[115]=

/Users/pyl/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2/Fi3.IN

le fichier Fi3.IN est ecrit, il faut le lancer!!!
pyl:~/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2 pyl$ ./bia

Resolution des equations dans le BIAcore

->
-->
-->
->

Da=7.191970 Pe=372.000000 K=1.000000
i1 = 0
i2 = 100
t = 15.450000 BM = 0.495000 CM = 0.990000

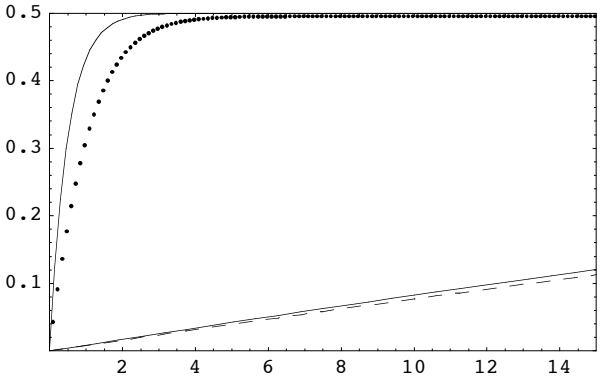
on trace ensuite.....

la sortie est dans
"BM1.OUT"

mais on a cree en relançant plusieurs fois ces dernières lignes 4 fichiers
(cp BM1.OUT BMD1.OUT etc)
"BMDX.OUT" pour D=X (0,1, 10 100)

In[116]:=

```
lst = ReadList[
   "/Users/pyl/macintoshHD/DOKUMENTS/Documents/2004/aliceF/PYL220501v2/BM1.OUT",
   {Number, Number, Number}];
bc = Table[{lst[[5 * i, 1]], lst[[5 * i, 2]]}, {i, 1, Dimensions[lst][[1]] / 5}];
tmax = 15;

sblzM = NDSolve[{
     B'[t] == (1 - B[t]) (K B[t] + (.807) (Da Pe^(-1 / 3))^(-1)) /
          (1 - B[t] + (.807) (Da Pe^(-1 / 3))^(-1) )
        - K B[t] ,
     B[0] == 0} //. valfp,
   {B[t]},
   {t, 0, tmax}];


sblz = NDSolve[{
     B'[t] == (1 - B[t]) (K B[t] + (.87) (Da Pe^(-1 / 3))^(-1)) /
          (1 - B[t] + (.87) (Da Pe^(-1 / 3))^(-1) )
        - K B[t] ,
     B[0] == 0} //. valfp,
   {B[t]},
   {t, 0, tmax}];



calcEq = Show[
  ListPlot[bc(*,PlotJoined→True *), (* PlotStyle→RGBColor[0,0,1],  *)
   DisplayFunction → Identity],

  Plot[ Evaluate[ B[t ] /. sblz], {t, 0, tmax},
   PlotRange → {{0, tmax }, {0, 1}}, (*PlotStyle→RGBColor[1,0,0],*)
   DisplayFunction → Identity],

  Plot[  Evaluate[ B[t ] /. sblzM], {t, 0, tmax},
   PlotRange → {{0, tmax }, {0, 1}},
   PlotStyle → Dashing[{0.025, 0.025}],
   (*PlotStyle→RGBColor[1,1,0],*)
   DisplayFunction → Identity],



  Plot[ Evaluate[ B[t ] /. Beq //. valfp], {t, 0, tmax},
   PlotRange → {{0, tmax }, {0, 1}}, (*PlotStyle→RGBColor[0,1,0],*)
   DisplayFunction → Identity],


  (*Plot[   Evaluate[ BEd[t  ]//.valfp],{t,0,tmax},
    PlotRange→{{0,tmax },{0,1}},PlotStyle→RGBColor[0,0,1],
    DisplayFunction→Identity],*)



  PlotRange → {{ 0, 15}, {0, .5}},
  DisplayFunction → $DisplayFunction,
  Frame → True]
```



Out[121]=

- Graphics -

In[122]:=

gD100 = %

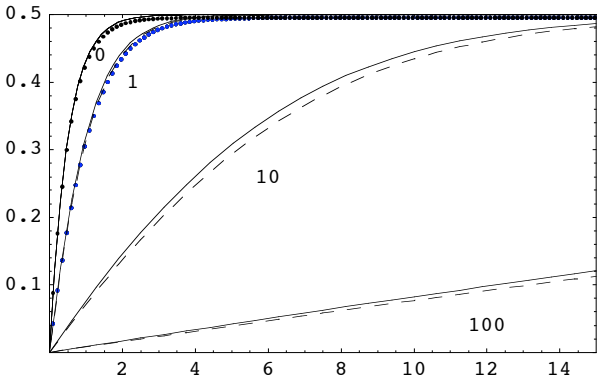
Out[122]=

- Graphics -

■ Comparaison des 4 cas

In[123]:=

```
Show[
  Graphics[Text["100", {12, .04}]],
  Graphics[Text["10", {6, .26}]],
  Graphics[Text["1", {2.3, .4}]],
  Graphics[Text["0", {1.4, .44}]],
  gD100 , gD10, gD1, gD0, PlotRange → {{ 0, 15}, {0, .5}}, Frame → True]
```

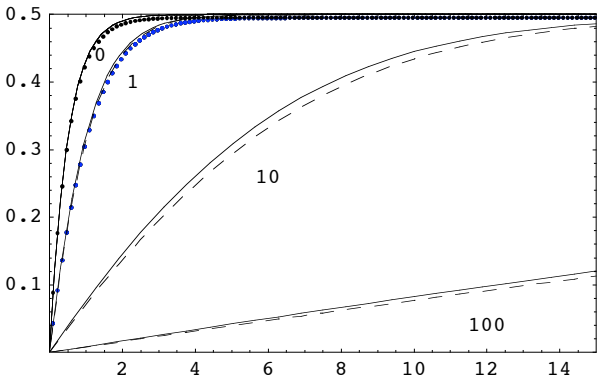


Out[123]=

- Graphics -

In[124]:=

```
Show[
 Graphics[Text["100", {12, .04}]],
 Graphics[Text["10", {6, .26}]],
 Graphics[Text["1", {2.3, .4}]],
 Graphics[Text["0", {1.4, .44}]],
 gD100 , gD10, gD1, gD0, PlotRange → {{ 0, 15}, {0, .5}}, Frame → True]
```

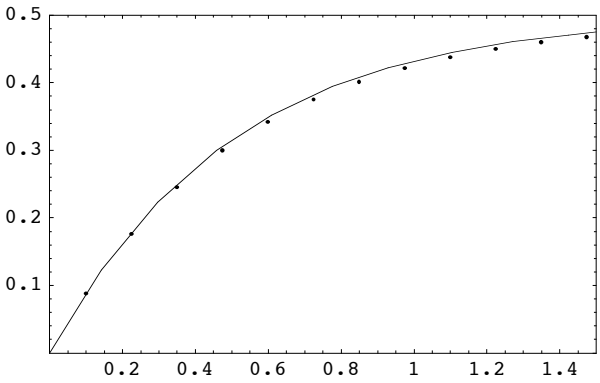


Out[124]=

- Graphics -

In[125]:=

```
Show[gD0, PlotRange → {{ 0, 1.5}, {0, .5}}, Frame → True]
```

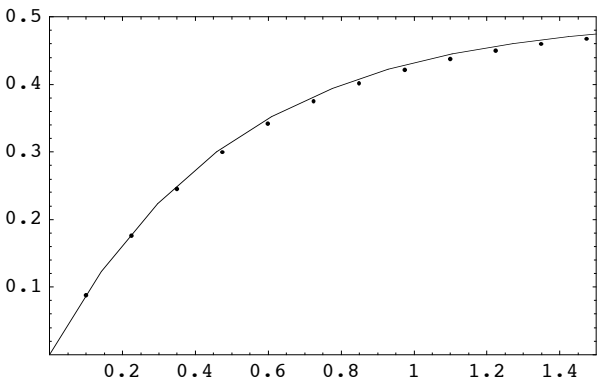


Out[125]=

- Graphics -

In[126]:=

```
Show[%, PlotRange → {{ 0, 1.5}, {0, .5}}, Frame → True]
```



Out[126]=

- Graphics -

In[127]:=

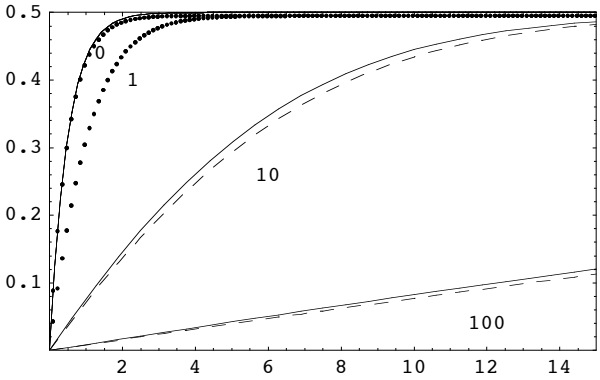
```
gD1 = %
```

Out[127]=

```
- Graphics -
```

In[128]:=

```
Show[
  Graphics[Text["100", {12, .04}]],
  Graphics[Text["10", {6, .26}]],
  Graphics[Text["1", {2.3, .4}]],
  Graphics[Text["0", {1.4, .44}]],
  gD100 , gD10, gD1, gD0, PlotRange → {{ 0, 15}, {0, .5}}, Frame → True]
```

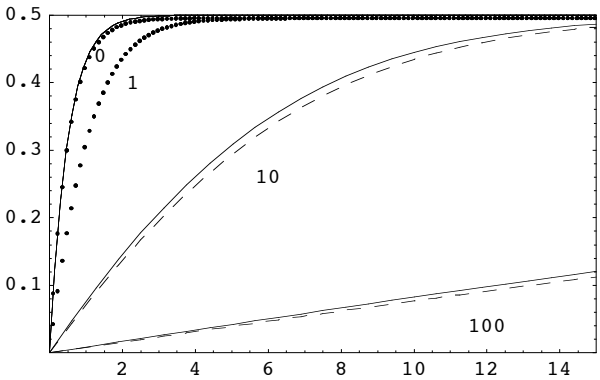


Out[128]=

```
- Graphics -
```

In[129]:=

```
Show[
 Graphics[Text["100", {12, .04}]],
 Graphics[Text["10", {6, .26}]],
 Graphics[Text["1", {2.3, .4}]],
 Graphics[Text["0", {1.4, .44}]],
 gD100 , gD10, gD1, gD0, PlotRange → {{ 0, 15}, {0, .5}}, Frame → True]
```

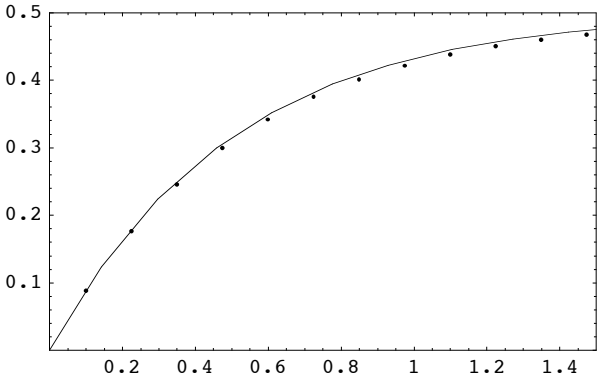


Out[129]=

```
- Graphics -
```

In[130]:=

```
Show[gD0, PlotRange → {{ 0, 1.5}, {0, .5}}, Frame → True]
```

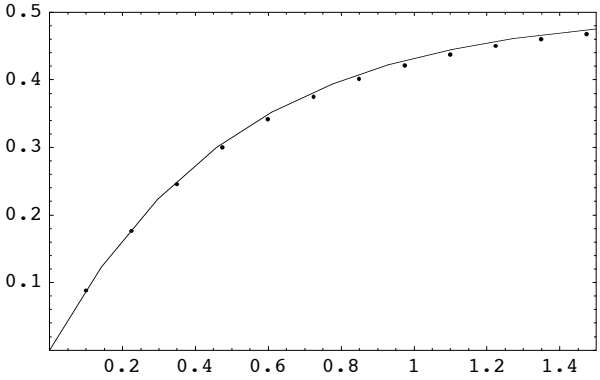


Out[130]=

```
- Graphics -
```

In[131]:=

```
Show[%, PlotRange → {{ 0, 1.5}, {0, .5}}, Frame → True]
```



Out[131]=

```
- Graphics -
```