

# Package ‘TimerQuant’

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|                   |                                                            |
|-------------------|------------------------------------------------------------|
| analyticSolutions | <i>Analytic model solutions for fluorescence intensity</i> |
|-------------------|------------------------------------------------------------|

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## Description

Time-dependent and steady-state analytic solution to one-step model for number of mature fluorophores. Where  $f$  is given as a parameter the returned value is transformed from a molecular population into a fluorescence intensity. For the function names, 0 refers to the dark population of non-mature fluorophores, and 1 to the mature, fluorescent population. 'ss' indicates steady-state solutions.  $t_{ss}$  is the time required to reach steady-state.

## Usage

```
tss(m, k)
x0ss(p, m, k)
x1(p, m, k, t, f=1)
x1ss(p, m, k, f=1)
x1fretFP1(p, m1, m2, k, t, E=0, f=1)
x1fretFP1ss(p, m1, m2, k, E=0, f=1)
```

## Arguments

|      |                                                                                                                                           |
|------|-------------------------------------------------------------------------------------------------------------------------------------------|
| $p$  | Protein production rate (molecules produced per unit time).                                                                               |
| $m$  | Maturation rate of fluorophore, which can be for either FP1 or FP2 (convert to maturation time with $\log(2)/m$ ).                        |
| $m1$ | Maturation rate of FP1.                                                                                                                   |
| $m2$ | Maturation rate of FP2.                                                                                                                   |
| $k$  | Protein degradation rate (convert to half-life with $\log(2)/k$ ).                                                                        |
| $t$  | Time (must be non-negative).                                                                                                              |
| $E$  | FRET coefficient representing energy transfer from FP1 to FP2.                                                                            |
| $f$  | Proportionality factor relating intensity to the number of molecules. When equal to one then the readout is number of molecules directly. |

## Value

A numeric specifying the model solution for the given parameters.

## Author(s)

Joseph D. Barry

**Examples**

```
t0 <- seq(0.001, 1000, by=0.1)
plot(t0, x1(p=10, m=log(2)/5, k=log(2)/100, t=t0), type="l", col="darkgreen",
     lwd=2, xlab="Time (min)", ylab="Number of mature fluorophores", cex.lab=1.4)
```

---

|       |              |
|-------|--------------|
| fitCV | <i>fitCV</i> |
|-------|--------------|

---

**Description**

Fits a smoothing line to coefficient of variation profiles.

**Usage**

```
fitCV(x, scaleLog10)
```

**Arguments**

**x** A dataframe with columns Time (FP maturation time) and CV (coefficient of variation of timer signal).

**scaleLog10** A logical indicating whether the points are spaced on the log10 scale or not.

**Value**

A dataframe containing fitted values and the minimum CV of the profile.

**Author(s)**

Joseph D. Barry

**Examples**

```
if (interactive()) vignette(topic="genPaperFigures", package="TimerQuant")
```

---

|          |                  |
|----------|------------------|
| FRETdata | <i>FRET Data</i> |
|----------|------------------|

---

**Description**

A three-dimensional array of dimensions FRET value x tFT x assay type containing FRET readouts.

**Usage**

```
FRETdata
```

---

|                 |                               |
|-----------------|-------------------------------|
| genRatioHeatmap | <i>generate ratio heatmap</i> |
|-----------------|-------------------------------|

---

## Description

Visualize timer ratios as a function of either FP1 or FP2 maturation time, and protein half-life.

## Usage

```
genRatioHeatmap(tRangeFP, Tfixed, TA, TB, channel, E, f=1, n, ramp)
```

## Arguments

|          |                                                                                                                         |
|----------|-------------------------------------------------------------------------------------------------------------------------|
| tRangeFP | Vector containing two numerics specifying the range of maturation times to display for the chosen fluorescence channel. |
| Tfixed   | The maturation time of the FP that will remain fixed.                                                                   |
| TA       | tFT half-life in location A.                                                                                            |
| TB       | tFT half-life in location B.                                                                                            |
| channel  | Integer specifying fluorescence channel to be varied (1 or 2).                                                          |
| E        | FRET value representing transfer from FP1 to FP2.                                                                       |
| f        | $f=f_2/f_1$ , the ratio of prefactors relating the number of molecules to the fluorescence intensity.                   |
| n        | Integer specifying the number of data points. Choose a higher n for a higher pixel density.                             |
| ramp     | Colour ramp, see <code>colorRampPalette</code> for more details.                                                        |

## Value

Returns a ggplot2 heatmap.

## Author(s)

Joseph D. Barry

## Examples

```
if (interactive()) vignette(topic="genPaperFigures", package="TimerQuant")
```

---

genTimeSteadyStateHeatmap  
*Time to reach steady-state*

---

### Description

Visualize the time to reach steady-state as a function of FP2 maturation time and protein half-life.

### Usage

```
genTimeSteadyStateHeatmap(tRangeFP2, tRangeHlife, n, ramp)
```

### Arguments

|             |                                                                                             |
|-------------|---------------------------------------------------------------------------------------------|
| tRangeFP2   | Vector containing two numerics specifying the range of FP2 maturation times.                |
| tRangeHlife | Vector containing two numerics specifying the range of protein half-lives.                  |
| n           | Integer specifying the number of data points. Choose a higher n for a higher pixel density. |
| ramp        | Colour ramp, see colorRampPalette for more details.                                         |

### Value

Returns a ggplot2 heatmap.

### Author(s)

Joseph D. Barry

### Examples

```
if (interactive()) vignette(topic="genPaperFigures", package="TimerQuant")
```

---

getBreaks10                      *Get log10 breaks*

---

### Description

Return breaks for each half-decade on the log10 scale, e.g. 1, 5, 10, 50, ...

### Usage

```
getBreaks10(x)
```

### Arguments

|   |                                                                       |
|---|-----------------------------------------------------------------------|
| x | A vector of numbers. Breaks will be calculated across the range of x. |
|---|-----------------------------------------------------------------------|

### Value

A sequence of breaks useful for ticks or labels on the log10 scale.

**Author(s)**

Joseph D. Barry

**Examples**

```
getBreaks10(c(1, 100))
```

---

getSpacedSeq

*Get Spaced Sequence*


---

**Description**

Return points nicely spaced for on the log10 scale.

**Usage**

```
getSpacedSeq(x, n)
```

**Arguments**

|   |                                                                                     |
|---|-------------------------------------------------------------------------------------|
| x | A vector of two numbers containing the minimum and maximum of the desired sequence. |
| n | The desired length of the sequence to be returned.                                  |

**Value**

A sequence of numbers with appropriate spacing for the log10 scale.

**Author(s)**

Joseph D. Barry

**Examples**

```
getSpacedSeq(c(1, 1000), n=10)
```

---

maturationData

*Maturation Data*


---

**Description**

A five-dimensional array of dimensions time (in minutes) x data columns x sample x view x tFT (identified by the RFP since sfGFP is present for all) containing fluorescence intensity readouts for the fluorophore maturation curves.

**Usage**

```
maturationData
```

---

`plotPrimordiumProfile` *Plot Primordium Profile*

---

**Description**

Visualizes primordium signal as a function of position with median and median absolute deviation across samples.

**Usage**

```
plotPrimordiumProfile(x, add, ylab, lwd, cex.lab, cex.axis, xlim, ylim, main,  
  col, lty, alpha)
```

**Arguments**

|                       |                                                                                            |
|-----------------------|--------------------------------------------------------------------------------------------|
| <code>x</code>        | A matrix of data where rows are samples and columns are sequential positions.              |
| <code>add</code>      | A logical indicating whether or not to add to the existing plot.                           |
| <code>ylab</code>     | The y-axis label.                                                                          |
| <code>lwd</code>      | Integer specifying width of lines.                                                         |
| <code>cex.lab</code>  | Integer specifying size of labels.                                                         |
| <code>cex.axis</code> | Integer specifying size of axis labels.                                                    |
| <code>xlim</code>     | An optional vector of length 2 specifying the limits for the x-axis.                       |
| <code>ylim</code>     | An optional vector of length 2 specifying the limits for the y-axis.                       |
| <code>main</code>     | Plot title.                                                                                |
| <code>col</code>      | Line colour.                                                                               |
| <code>lty</code>      | Style of line                                                                              |
| <code>alpha</code>    | A numeric between zero and one specifying the level of transparency for the shaded region. |

**Value**

Produces a plot of signal vs position summarizing across multiple primordium samples.

**Author(s)**

Joseph D. Barry

**Examples**

```
if (interactive()) vignette(topic="genPaperFigures", package="TimerQuant")
```

---

|                  |                          |
|------------------|--------------------------|
| profileGradients | <i>Profile Gradients</i> |
|------------------|--------------------------|

---

### Description

A three-dimensional array of dimensions tFT x sample x position containing ratio readouts for migrating posterior lateral line primordia.

### Usage

```
profileGradients
```

---

|                  |                                           |
|------------------|-------------------------------------------|
| ratioSteadyState | <i>analytic function ratioSteadyState</i> |
|------------------|-------------------------------------------|

---

### Description

Steady-state analytic solution to one-step model for the ratio of mature to non-mature fluorophores.

### Usage

```
ratioSteadyState(T1, T2, halfLife, E=0, f=1)
```

### Arguments

|          |                                                                                                                                 |
|----------|---------------------------------------------------------------------------------------------------------------------------------|
| T1       | Maturation time of fluorescent protein 1 (FP1, fast maturing).                                                                  |
| T2       | Maturation time of fluorescent protein 2 (FP2, slow maturing).                                                                  |
| halfLife | Protein half-life.                                                                                                              |
| E        | FRET value representing transfer from FP1 to FP2.                                                                               |
| f        | $f=f_2/f_1$ , the ratio of prefactors relating the number of molecules to fluorescence intensity for each fluorescence channel. |

### Value

A numeric specifying the model steady-state solution for the given parameters.

### Author(s)

Joseph D. Barry

### Examples

```
halfLifeSeq <- seq(1, 2000, by=0.1)
plot(halfLifeSeq, ratioSteadyState(T1=5, T2=100, halfLife=halfLifeSeq),
     type="l", lwd=2, ylim=c(0, 1), xlab="tFT half-life (min)",
     ylab="Steady-state ratio", cex.lab=1.4, log="x", col="red")
```

---

|                    |                                             |
|--------------------|---------------------------------------------|
| ratioTimeDependent | <i>analytic function ratioTimeDependent</i> |
|--------------------|---------------------------------------------|

---

## Description

Steady-state analytic solution to one-step model for the ratio of mature to non-mature fluorophores.

## Usage

```
ratioTimeDependent(T1, T2, halfLife, t, E=0, f=1)
```

## Arguments

|          |                                                                                                   |
|----------|---------------------------------------------------------------------------------------------------|
| T1       | Maturation time of fluorescent protein 1 (FP1, fast maturing).                                    |
| T2       | Maturation time of fluorescent protein 2 (FP2, slow maturing)                                     |
| halfLife | Protein half-life.                                                                                |
| t        | Time, which must be non-negative.                                                                 |
| E        | FRET value representing energy transfer from FP1 to FP2.                                          |
| f        | $f=f_2/f_1$ , the ratio of prefactors relating the number of molecules to fluorescence intensity. |

## Value

A numeric specifying the model time-dependent solution for the given parameters.

## Author(s)

Joseph D. Barry

## Examples

```
tSeq <- seq(0.1, 300, by=0.1)
plot(tSeq, ratioTimeDependent(T1=5, T2=100, halfLife=30, t=tSeq, E=0, f=1), type="l", lwd=2,
     xlab="time (min)", ylab="ratio", cex.lab=1.4, col="black", ylim=c(0, 0.3))
points(tSeq, ratioTimeDependent(T1=5, T2=100, halfLife=30, t=tSeq, E=0.4, f=1), type="l", lwd=2,
      col="red")
abline(h=ratioSteadyState(T1=5, T2=100, halfLife=30, E=0, f=1), lty=2, col="black")
abline(h=ratioSteadyState(T1=5, T2=100, halfLife=30, E=0.4, f=1), lty=2, col="red")
```

---

|              |                                 |
|--------------|---------------------------------|
| runShinyApps | <i>Run R-shiny applications</i> |
|--------------|---------------------------------|

---

**Description**

Wrapper functions that run shiny apps located in extdata subdirectory of R package.

**Usage**

```
runChooseFP2App()  
runTimerModellingApp()
```

**Author(s)**

Joseph D. Barry

**Examples**

```
runChooseFP2App()  
  
runTimerModellingApp()
```

---

|        |               |
|--------|---------------|
| signal | <i>Signal</i> |
|--------|---------------|

---

**Description**

Computes timer signal (without additive noise) for a set of model parameters.

**Usage**

```
signal(T1, T2, TA, TB, E=0)
```

**Arguments**

|    |                                                           |
|----|-----------------------------------------------------------|
| T1 | Maturation time of fluorescent protein 1 (fast maturing). |
| T2 | Maturation time of fluorescent protein 2 (slow maturing). |
| TA | Minimum protein half-life.                                |
| TB | Maximum protein half-life.                                |
| E  | FRET value representing transfer from FP1 to FP2.         |

**Value**

A numeric specifying the timer signal.

**Author(s)**

Joseph D. Barry

**Examples**

```
signal(T1=5, T2=60, TA=30, TB=180, E=0)
signal(T1=5, T2=60, TA=30, TB=180, E=0.5)
```

---

|                 |                               |
|-----------------|-------------------------------|
| simulatedSignal | <i>Simulated Timer Signal</i> |
|-----------------|-------------------------------|

---

**Description**

Additive error model for timer signal.

**Usage**

```
simulatedRatio(T1, T2, hLife, sigmaAdd, p, E)
simulatedSignal(T1, T2, TA, TB, sigmaAdd, p, E)
simulatedSignalN(T1, T2, TA, TB, sigmaAdd, N, p, E)
```

**Arguments**

|          |                                                                             |
|----------|-----------------------------------------------------------------------------|
| T1       | Maturation time of fluorescent protein 1 (FP1, fast maturing).              |
| T2       | Maturation time of fluorescent protein 2 (FP2, slow maturing).              |
| hLife    | Protein half-life.                                                          |
| TA       | Minimum protein half-life.                                                  |
| TB       | Maximum protein half-life.                                                  |
| sigmaAdd | Standard deviation of normal distribution from which noise terms are drawn. |
| p        | Protein production rate (molecules produced per unit time).                 |
| E        | FRET value representing energy transfer from FP1 to FP2.                    |
| N        | Number of simulation realizations.                                          |

**Value**

Returns simulated values for ratios or timer signal.

**Author(s)**

Joseph D. Barry

**Examples**

```
if (interactive()) vignette(topic="genPaperFigures", package="TimerQuant")
```

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