Using the 5-minute time interval, the absolute growth increment (AGI) was computed, defined as the OD680 change between the consecutive measurements d(OD680)/dt. Values above 0 represent OD680 increase and growth of the picocyanobacteria cultures. Increase of the AGI curve reflects acceleration of the growth, and decrease the deceleration phase, consequently (Fig. 1).

Based on the AGI were determined the acceleration phase length (AccLen), defined as the time (expressed in h) between the start of the photoperiod and the time of the tMaxDGI. This relationship was defined as diel growth symmetry (GS; Eq. (1)).

GS(h)=AccLen/(Photoperiod length)  (1)

The maximum value within each photoperiod was called the maximum daily growth increment (maxDGI), and the highest of all of them, was recorded for each experiment setup and referred to as the maximum absolute growth increment (maxAGI). The maxAGI marked the point of the sigmoid curve fitted to the growth curve, indicating the transition point leading to the pre-stationary phase. Additionally, the total daily growth (TDG), defined as the difference in OD680 at the end and at the beginning of each photoperiod was estimated.

Fig.Caption

\*\*A) Example of a growth curve (tracked as OD~680~; red solid line, left y-axis) of a \*Synechococcus\* sp. strain vs. elapsed time (h)\*\*; 1^st^ derivative of OD~680~ taken over 1 h increments (black solid line, right y-axis). The vertical dotted lines indicate the time to reach the diel maximum of the 1^st^ derivative of growth (vertical dotted line; tMaxDG). The vertical blue solid line represents the time when the cultures reached their maximum absolute hourly growth (tMaxAHG), taken as an index of transition from exponential to pre-stationary growth phases. \*\*B) An expanded view of one diel cycle.\*\* Within a diel period the acceleration length (AccLen) is the time between the start of the photoperiod and the time to reach the diel maximum of the 1st derivative of growth (vertical dotted line; tMaxDG). Deceleration length (DecLen) is then the time from tMaxDG to the end of the photoperiod. We then define the diel growth symmetry (GS) as AccLen/DecLen.

## Changes of diel growth symmetry {.unnumbered}

Supplemental figures show consistent variations in short term growth rates over diel cycles. We sought to analyze the intra-diel patterns of growth, initially by separating growth over the photoperiod into an acclerating phase of increasing hourly growth increments, and a deceleration phase, of decreasing hourly growth increments.

Research Question:

Do strains show consistent patterns of diel growth across cumulative diel photon doses?

No.

The length of the diel acceleration phase of growth increases with increasing photoperiod, but the slope of accleration phase vs. cumulative diel photon dose decreases with increasing peak PAR.

During pre-stationary phase these responses dampen but persist.

```{r AccLen, fig.cap = AccLen\_cap, fig.height = 6, fig.width = 8, echo = FALSE}

AccLen\_cap<- glue("\*\*Hours of photoperiod to reach maximum hourly growth vs. cumulative diel photon dose (µmol photons m^−2^d^−1^).\*\* Time-resolved growth was estimated over hourly intervals for two PhycoCyanin(PC)-rich cultures (056, 077) and two PhycoErythrin(PE)-rich cultures (048, 127) of \*Synechococcus\* sp. originating from the Baltic Sea. Cultures were grown at 30 (dark gray), 90 (light gray), 180 (purple), 300 (red), or 900 (yellow) peak PAR µmol photons m^−2^s^−1^ (µE); and photoperiods of 8 (square), 12 (circle), or 16 (triangle) h. The horizontal lines indicate the time (h) to reach the maximum light for a given photoperiod; 4 h for the 8 h photoperiod; 6 h for the 12 h photoperiod; or 8 h for the 16 h photoperiod. Figure presents data (small symbols) and means (big symbols) from exponential phase of growth, or from pre-stationary phase of growth, \*n\* = 1-5.", .sep = " ")

knitr::include\_graphics(file.path(FiguresFP,"Fig\_AccLen.png"))

```

Research Question:

Do strains show consistent patterns of diel symmetry (AccLen/DecLen) across cumulative diel photon doses?

Yes.

The ratio of the diel acceleration phase of growth to the deceleration phase shows a consistent exponential decay in relation to cumulative photon dose, across different combinations of photoperiod and peak PAR.

Although all strains shows this response pattern, the exponential decay model parameters differ significantly among strains.

During pre-stationary phase this response dampens and even disappears.

```{r GS, fig.cap = GS\_cap, fig.height = 6, fig.width = 8, echo = FALSE}

GS\_cap<- glue("\*\*Index of diel growth symmetry (AccLen/DecLen ratio) vs. cumulative diel photon dose (µmol photons m^−2^d^−1^).\*\* Diel growth symmetry was estimated for two PhycoCyanin(PC)-rich cultures (056, 077) and two PhycoErythrin(PE)-rich cultures (048, 127) of \*Synechococcus\* sp. originating from the Baltic Sea. Cultures were grown at 30 (dark gray), 90 (light gray), 180 (purple), 300 (red), or 900 (yellow) peak PAR µmol photons m^−2^s^−1^ (µE); and photoperiods of 8 (square), 12 (circle), or 16 (triangle) h. Figure presents data (small symbols) and means (big symbols) from exponential phase of growth, or from pre-stationary phase of growth, \*n\* = 1-5. Blue solid line shows single phase exponential decay fit for data from each strain and growth phase, with fit parameters presented. Different lowercase letters indicate significant differences between the fit models for different strains within a given phase of growth. Different uppercase letters indicate significant differences between the fit models for different phases of growth within a given strain (ANOVA; \*p\* < 0.05).", .sep = " ")

knitr::include\_graphics(file.path( FiguresFP,"Fig\_GS.png"))

```

Statistical analysis

The trends of change in the growth symmetry (GS) were tested using the Mann-Kendall test [28] on the ±5 photoperiods to avoid noise during the first few days of the experiment.

Results

**## Changes of diel growth symmetry**

Supplemental figures show consistent variations in short term growth rates over diel cycles.  We sought to analyze the intra-diel patterns of growth, initially by separating growth over the photoperiod into an acclerating phase of increasing hourly growth increments, and a deceleration phase, of decreasing hourly growth increments.

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