
Stable Running with Segmented Legs

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seit 1558



spring-like leg behavior

[Blickhan 1989, McMahon & Cheng 1990]

self-stability

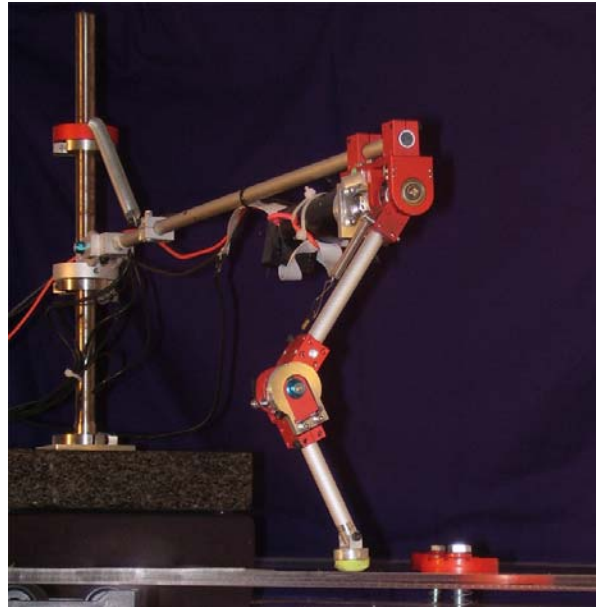
[Seyfarth et al. 2002]

segmented leg structure

compliance at joint level

[Guenther et al. 2002]

JenaHopper



monopedal robot

no pitch motion

low leg mass

hip motor

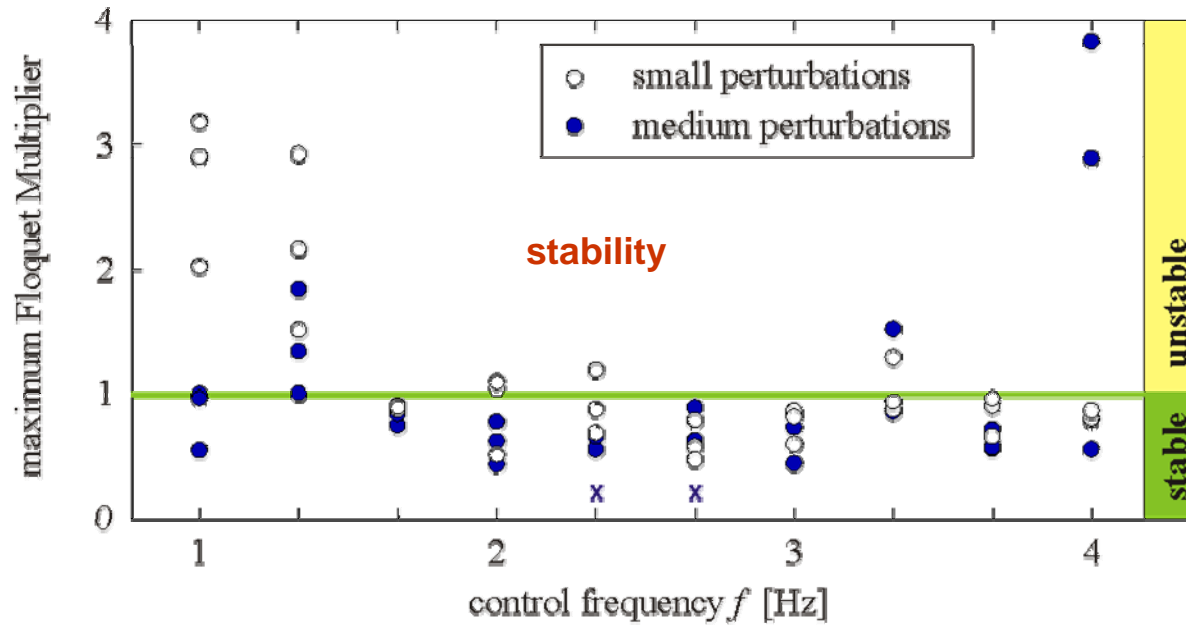
sinusoidal hip oscillation

spring-like leg behavior

stability ?

segmented leg structure

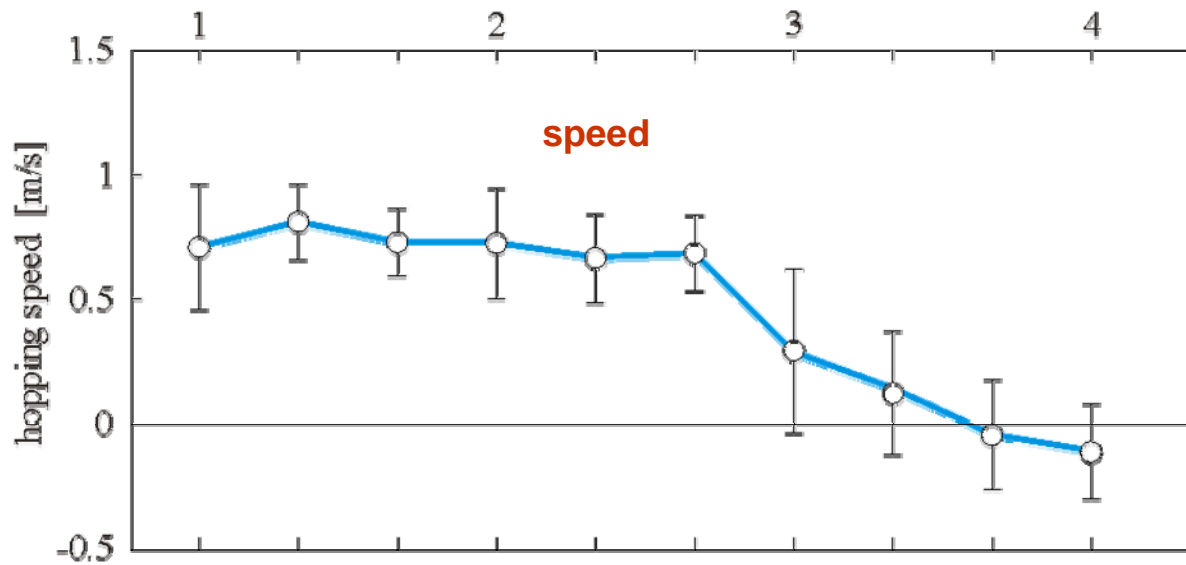
compliance at joint level



simple hip oscillation

sufficient for
legged locomotion

[Seyfarth et al. 2006]



open questions:

Stable hopping over a wide range of **hip frequencies**

Stable motion although **angle of attack** is not controlled

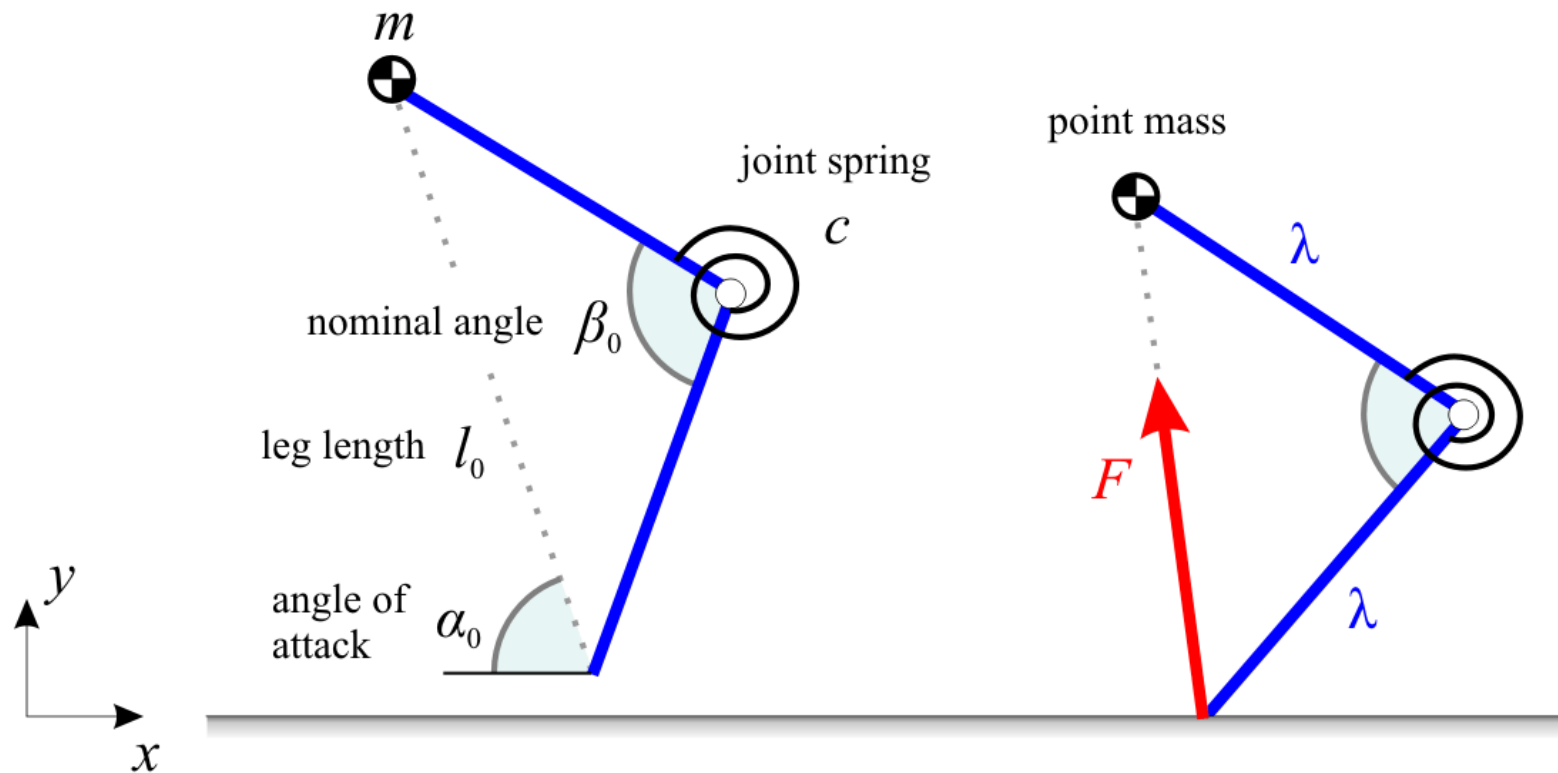
Nonlinear joint stiffness observed in human running

Leg design may influence stability

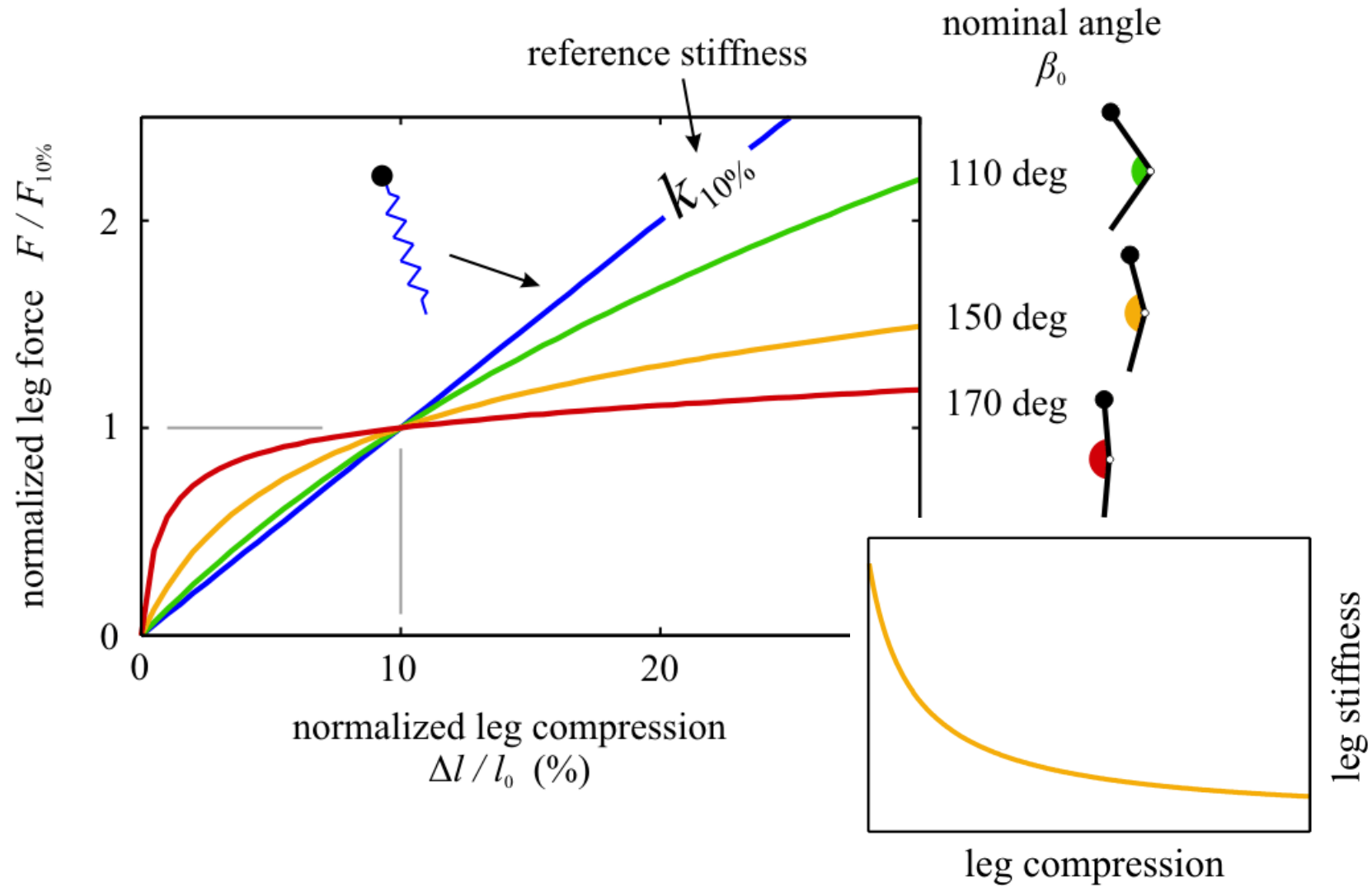
Disadvantages of the leg design

Influence of leg segmentation on running stability?

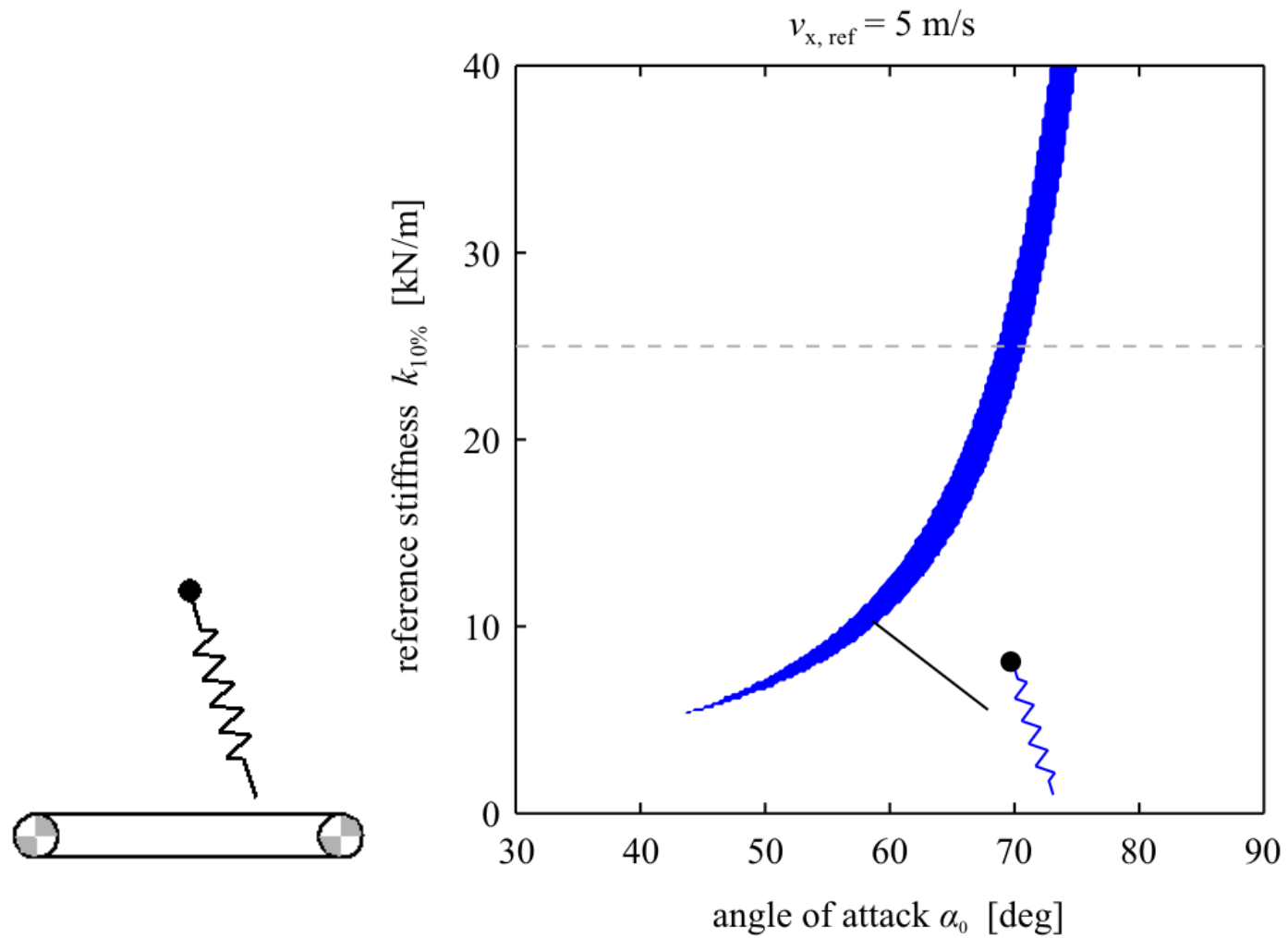
Two-Segment Leg



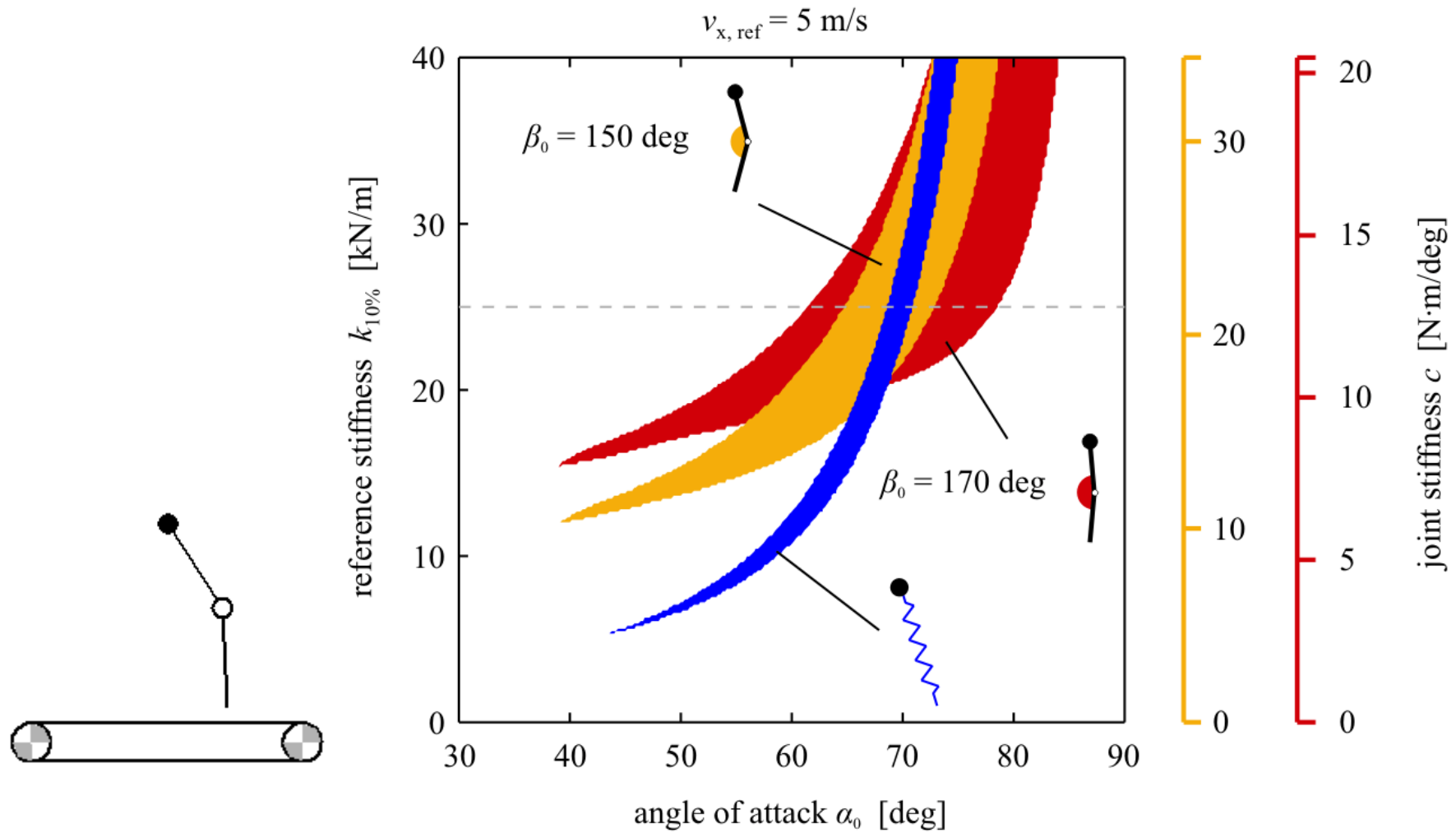
Force-Length Relationship



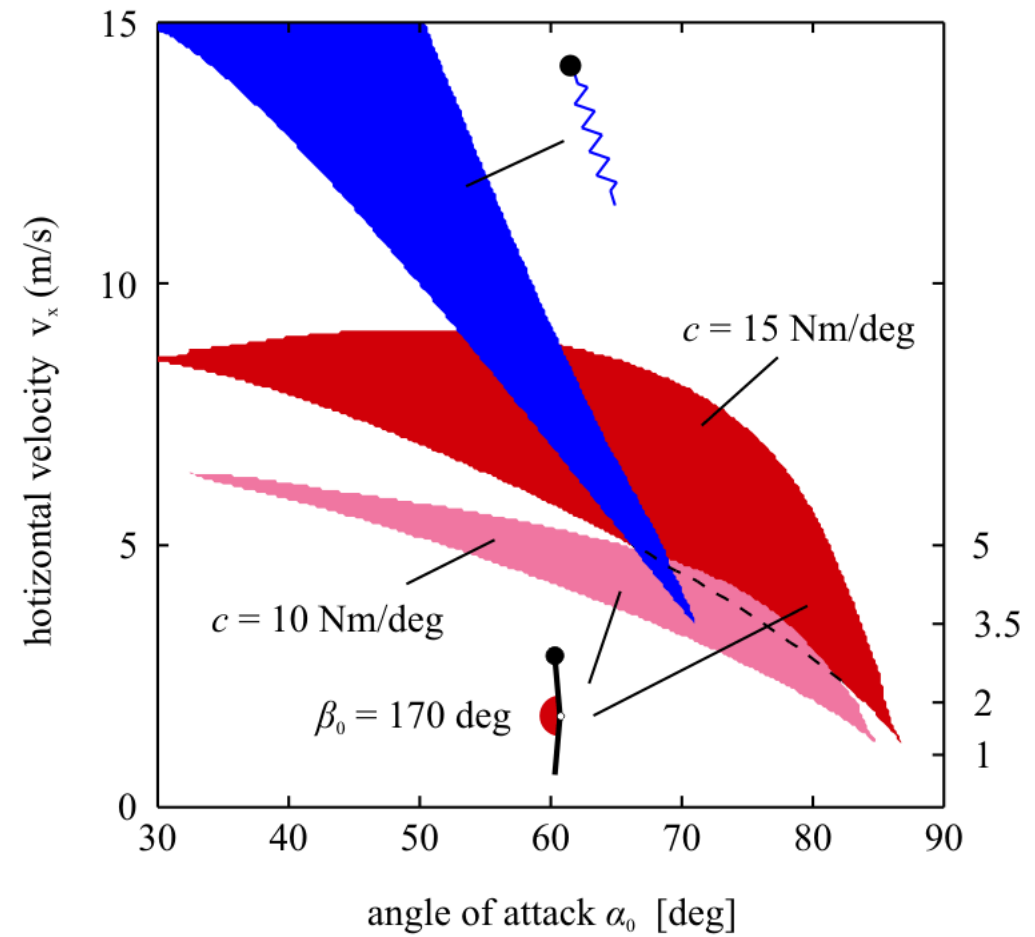
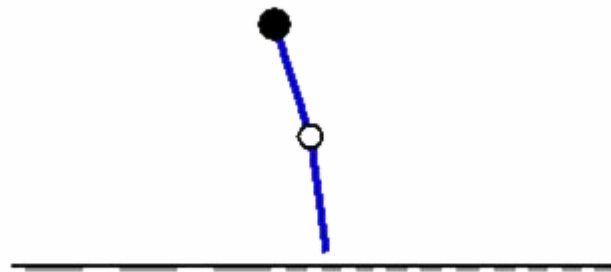
Self-Stability in Running



Self-Stability in Running

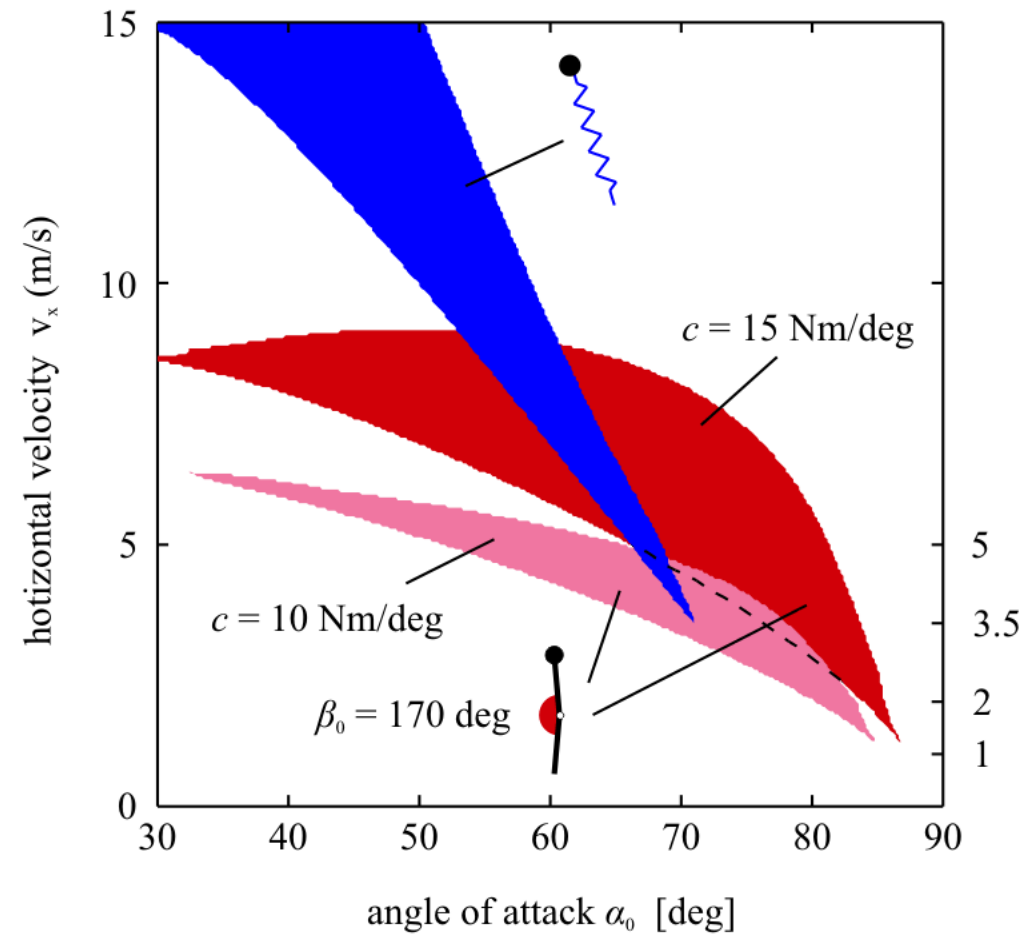
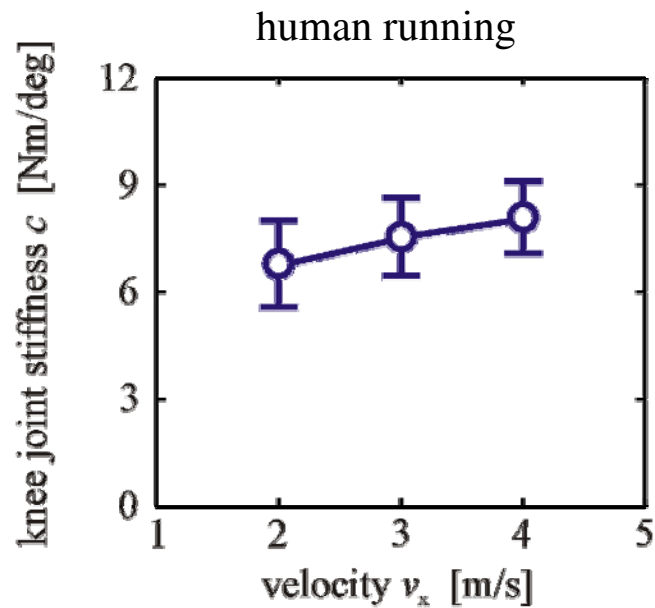


Self-Stability in Running

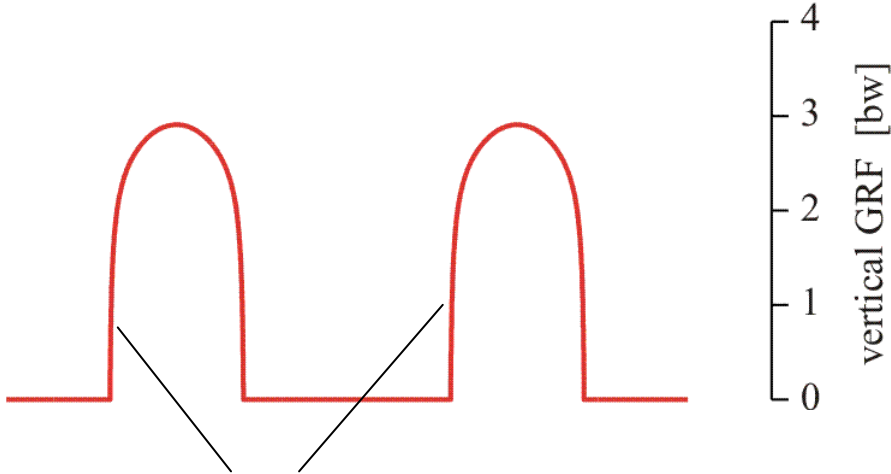
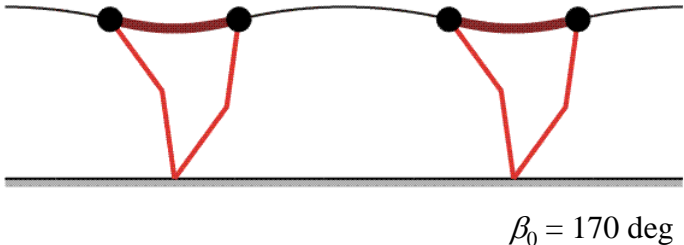


Joint stiffness at variable Speed

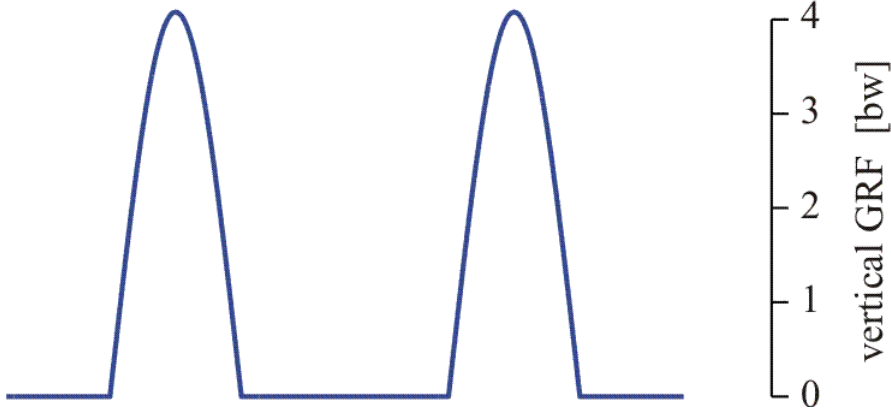
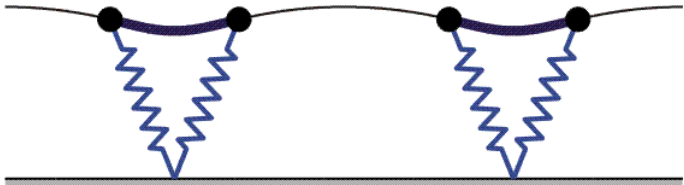
Hypothesis:
**increasing joint stiffness
 with increasing running speed**



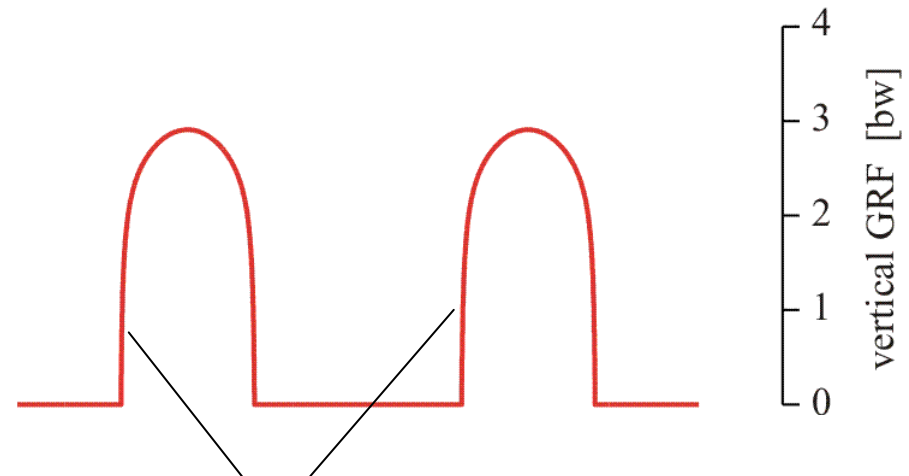
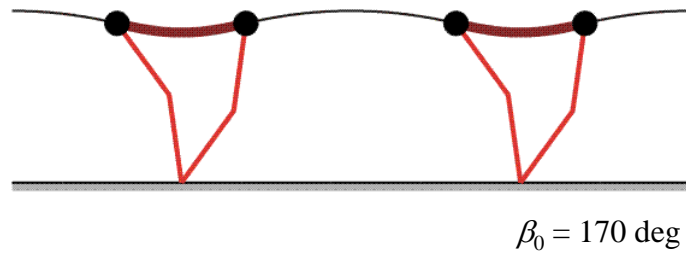
Dynamics



may lead to large impact forces

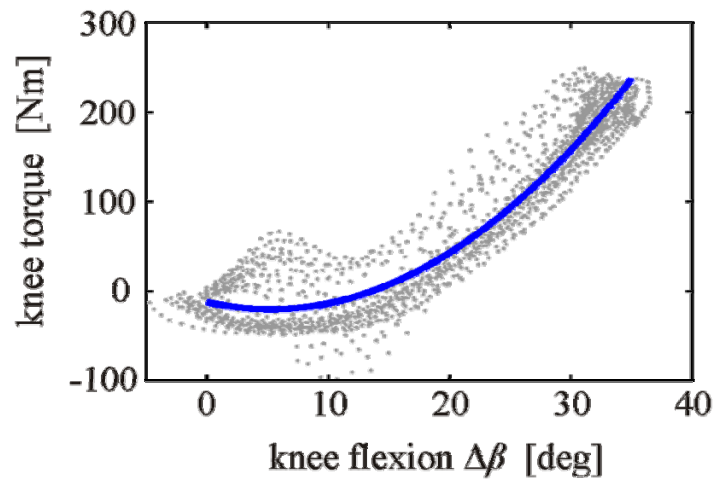


Dynamics



may lead to large impact forces

human experiment



nonlinear joint stiffness

third leg segment

Segmented legs with elastic joints ...

... demonstrate passively adaptable leg compliance

... facilitate self-stable running

... support running at low velocities

... require adjustment of joint stiffness to speed



Publications

Rummel J. and Seyfarth A., Int. J. Robot. Res. (accepted)

Rummel J. et al., IEEE Int. Conf. Robot. Autom., 2008



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