"Make storage rings great again"  Properties of electron storage rings:
- high repetition rate (revolution frequency several MHz, typical bunch rate 500 MHz)
- high stability, same charge each turn, natural damping mechanisms, feedback systems
- high efficiency, only radiation losses fed back by radiofrequency (RF) system

"I have a dream" ... that storage rings could be driven by laser instead of RF wave:
- energy modulation in undulator instead of acceleration in RF cavity
- wavelengths:
  - typical RF 60 cm, X band 3 cm (possible)
  - vis. laser 500 nm, soft X-rays 1 nm (very difficult)
- main issue: electron path variation < wavelength

"Turn, turn, turn"  Steady-state microbunching [3-5] = density modulation at every turn, options:
- sustained microbunching ↔ modulation created and undone every turn
- continuous wave ↔ pulsed laser (several MHz)
- single laser-electron interaction ↔ multiple interactions
- single laser pass ↔ enhancement cavity

"Fascinating"  Example with 50 W cw CO₂ laser:
- factor 60000 in wavelength and bunch rate compared to RF
- coherent emission at modulation wavelength and harmonics
- train of ultrashort bunches (fraction of ~15 fs bucket)
- single ultrashort bunches by removing adjacent bunches

"Yes, we can"  Required storage ring properties [7]:
- isochronous ring minimizing \( \Delta \varepsilon = \left( R_{s1}^2 \cdot \sigma_{\epsilon}^2 + R_{s2}^2 \cdot \sigma_{\epsilon}^2 + R_{s3}^2 \cdot \sigma_{\epsilon}^2 \right) \)
- control of higher-order momentum compaction and matrix elements
- minimize dispersion, e.g. multibend achromat lattice [8], reducing effects of matrix elements \( R_{s1} \) and \( R_{s2} \) [9],
- of stochastic photon emission [10]
- test experiment at MLS in Berlin [5], energy modulation with microbunching after 1 turn
- next step: a demonstrator ring?

"A small step for mankind" ... but a novel type of "advanced" accelerator:
- storage ring driven by laser or RF+laser combination
- bunch length similar to linac or laser-plasma accelerator, but MHz bunch rate
- FEL-like coherent emission of radiation
- new parameter regime for storage ring physics: \( 10^7 \) bunches, \( 10^7 \) multibunch modes ...

References:

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