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LIGHT POLLUTION

Dr. Harald Pier

harald.pier@cenogent.com

cenogent – TOPICS

- creating light & illumination with solid state light sources (IR/VIS/UV)
- optics, photonics, LED, laser, converter materials (phosphors)
- automotive, aerospace, medical
- Intellectual property rights & protection
- patent searches & analysis
- lighting for living beings (human physiology, animals & plants)

cenogent - PRODUCTS

DJI Phantom 4
search light



© POSSI.DE



Light copter, 80min battery-
only flight time, 20000lm



>500m



Rally car lights

LIGHT POLLUTION IN EUROPE



LIGHT POLLUTION IN SWITZERLAND

Domdidier 400 m, distance 50 km
still visible

Other (sports) facilities

Source: <http://www.jrm-photoworks.com>

PHOTO TAKEN FROM
«HASENMATT», 1400M

SOME STATISTICS

- 1992 → 2017: at least +49%
- possibly as much as 270% globally
- huge regional variations, mostly increase
- satellite sensor not sensitive to blue part of emission spectra
- therefore shift to LED lighting may hide real effect

*remote sensing*

Article

First Estimation of Global Trends in Nocturnal Power Emissions Reveals Acceleration of Light Pollution

Alejandro Sánchez de Miguel ^{1,2,3,*} , Jonathan Bennie ^{4,†} , Emma Rosenfeld ¹, Simon Dzurjak ¹ and Kevin J. Gaston ¹

¹ Environment and Sustainability Institute, University of Exeter, Penryn, Cornwall TR10 9FE, UK; E.Rosenfeld@exeter.ac.uk (E.R.); s.dzurjak@exeter.ac.uk (S.D.); K.J.Gaston@exeter.ac.uk (K.J.G.)

² Dept. Física de la Tierra y Astrofísica, Instituto de Física de Partículas y del COSMOS (IPARCOS), Universidad Complutense de Madrid, 28040 Madrid, Spain

³ Instituto de Astrofísica de Andalucía, Glorieta de la Astronomía, s/n, 18008 Granada, Spain

⁴ Centre for Geography and Environmental Science, University of Exeter, Penryn, Cornwall TR10 9FE, UK; J.J.Bennie@exeter.ac.uk

* Correspondence: alejasan@ucm.es

† These authors contributed equally.

Abstract: The global spread of artificial light is eroding the natural night-time environment. The estimation of the pattern and rate of growth of light pollution on multi-decadal scales has nonetheless proven challenging. Here we show that the power of global satellite observable light emissions increased from 1992 to 2017 by at least 49%. We estimate the hidden impact of the transition to solid-state light-emitting diode (LED) technology, which increases emissions at visible wavelengths undetectable to existing satellite sensors, suggesting that the true increase in radiance in the visible spectrum may be as high as globally 270% and 400% on specific regions. These dynamics vary by region, but there is limited evidence that advances in lighting technology have led to decreased emissions.

 check for updates

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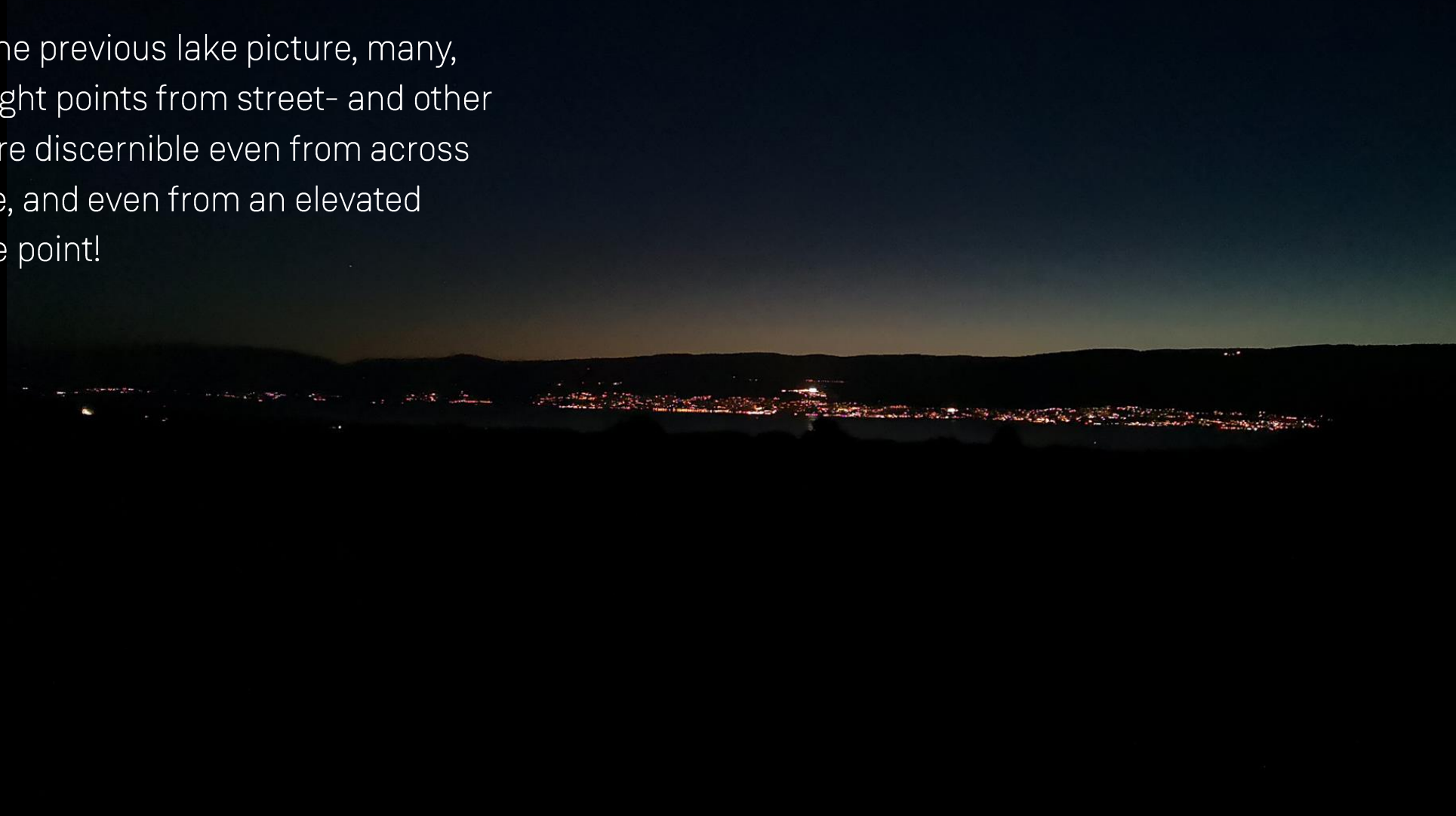
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LIGHT POLLUTION, NEUCHÂTEL COASTLINE

As on the previous lake picture, many, many light points from street- and other lights are discernible even from across the lake, and even from an elevated vantage point!



LIGHT POLLUTION IN DETAIL (LED solution !)

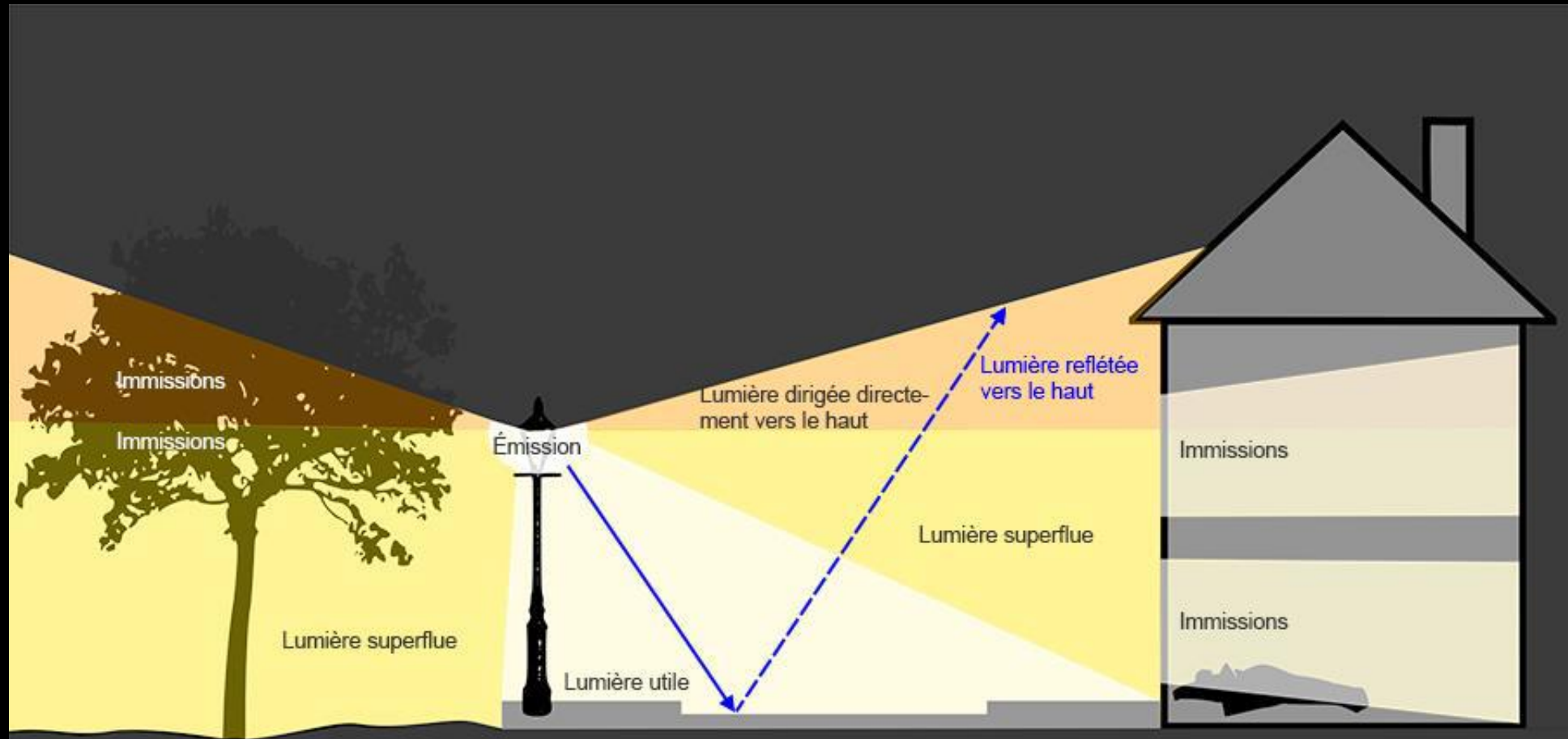


illuminated facades

direct visibility of light sources outside target area

illuminated non-target area

ARTIFICIEL LIGHTING AT NIGHT (#ALAN)



Konsultation «Vollzugshilfe Lichtemissionen», Seite 12

https://www.bafu.admin.ch/dam/bafu/de/dokumente/elektrosmog/uv-umwelt-vollzug/empfehlungen-zur-vermeidung-von-lichtemissionen.pdf.download.pdf/UV-2117-D_Lichtemissionen.pdf

grafik by odigrafik.ch

ARTIFICIAL LIGHT AT NIGHT, FINDINGS

- Light pollution has three components:
 1. backreflection from lit target surfaces: **unavoidable (actually the objective....)**
 2. illuminated surfaces outside target: **avoidable**
 3. backreflection from those surfaces: **avoidable**
 4. direct visibility of light sources (light points): **avoidable**
- > 98% of all outdoor lighting still has components 2. - 4., even LED-based lighting solutions.

EFFECTS ON PLANTS, INSECTS, ANIMALS, HUMANS

- plants growth cycles are being disturbed
- they may become less resilient



WHAT HAPPENED TO INSECTS?

Common
observation
in the 80ies/90ies
after long summer
car trips

only gone because of
improved
car aerodynamics ?



WHAT HAPPENED TO INSECTS ?

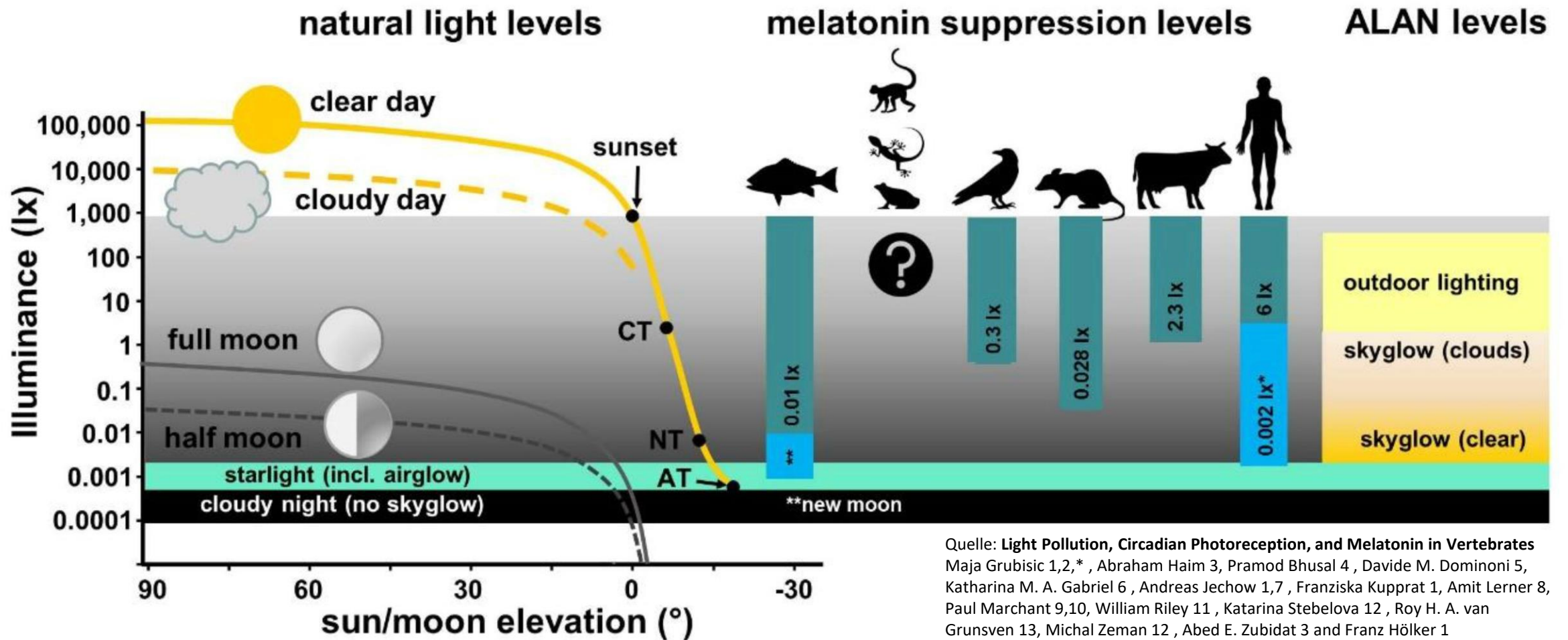
100 billion insects / year lost
at streetlights in Germany
alone !

Impact on food chain

night active butterflies, moths

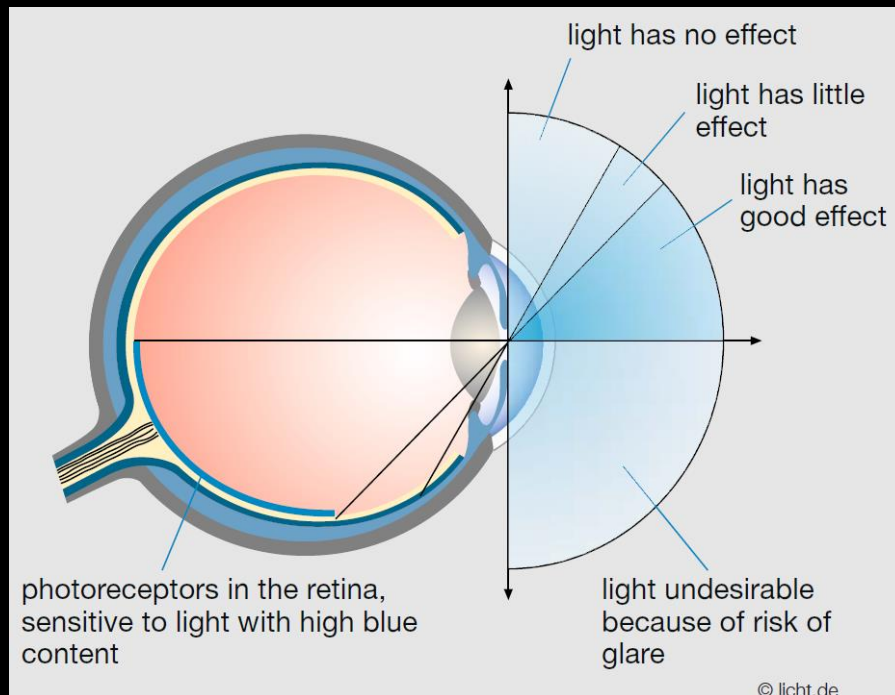


EFFECTS OF LIGHT ON ANIMALS

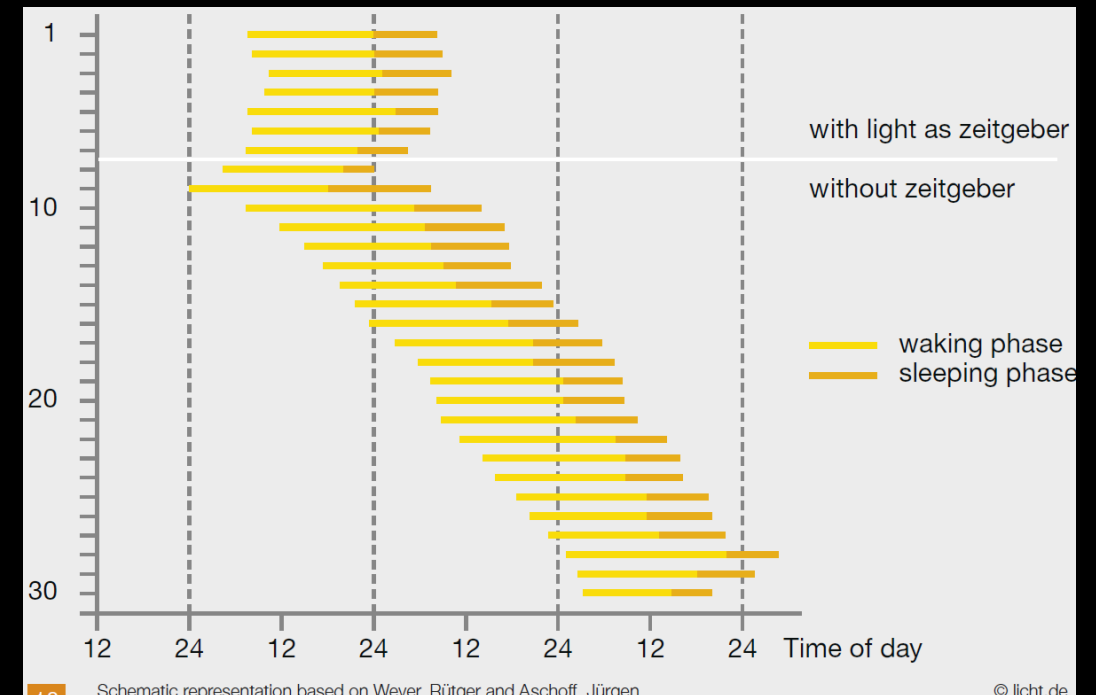


BIOLOGICAL EFFECTS ON HUMANS (ANIMALS)

- BLUE PART OF LIGHT SPECTRUM
- INCIDENCE ANGLE IS CRITICAL



DAYS



WHY REDUCING LIGHT POLLUTION IS ESSENTIAL

- Cause and effects are well known by now
- It becomes clear that light pollution has much worse effects than previously thought
- Massive threat to insect population
- Equally negative effects on wildlife, birds, but also water habitats
- Is threatening for humans as well



11 pressing research questions on how light pollution affects biodiversity

Provisionally accepted

The final, formatted version of the article will be published soon

Notify me

Franz Hölker^{1, 2*}, Janine Bolliger³, Thomas W. Davies⁴, Simone Giavi⁵, Andreas Jechow¹, Gregor Kalinkat¹, Travis Longcore⁶, Kamiel Spoelstra⁷, Svenja Tidau⁴, Marcel E. Visser⁷ and Eva Knop⁸

Effects of LED street-light temperature on insect and bat abundance in a landscape context - an energy-change impact assessment

WSL
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sur la forêt, la neige
et le paysage WSL

Forêt

Paysage

Biodiversité

Dangers naturels

cenogent SARL
Neige et glace

Empfehlungen zur Vermeidung von Lichtemissionen

Stand 2021



Grundsätze zur Begrenzung von Lichtemissionen (7-Punkte-Plan)



[1] Notwendigkeit

Braucht es eine Beleuchtung?

- Nur beleuchten, was beleuchtet werden muss.
- Kap. 3.3.1



[2] Intensität / Helligkeit

Wie hell muss die Beleuchtung sein?

- Nur so hell beleuchten, wie nötig.
- Kap. 3.3.2



[3] Lichtspektrum / Lichtfarbe

Ist das Lichtspektrum richtig gewählt?

- Lichtspektrum auf Beleuchtungszweck und Umgebung abstimmen.
- Kap. 3.3.3



[4] Auswahl und Platzierung der Leuchten

Ist der passende Leuchtentyp gewählt und geeignet platziert?

- Die Beleuchtung soll möglichst präzise und ohne unnötige Abstrahlungen in die Umgebung erfolgen.
- Kap. 3.3.4



[5] Ausrichtung

Sind die Leuchten optimal ausgerichtet?

- Grundsätzlich von oben nach unten beleuchten.
- Die Leuchten bei der Montage präzise ausrichten.
- Kap. 3.3.5



[6] Zeitmanagement / Steuerung

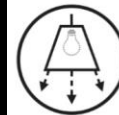
Wann braucht es welche Beleuchtung?

Kann die Beleuchtung zeitweise ausgeschaltet oder reduziert werden?

- Bezogen auf die Tages- bzw. Nachtzeit?
- Bezogen auf die Jahreszeit (saisonal)?

Kann die Beleuchtung aktiv (bedarfsgerecht) gesteuert werden?

- Die Beleuchtung nach Möglichkeit bedarfsgerecht steuern und zeitweise ausschalten oder reduzieren.
- Kap. 3.3.6

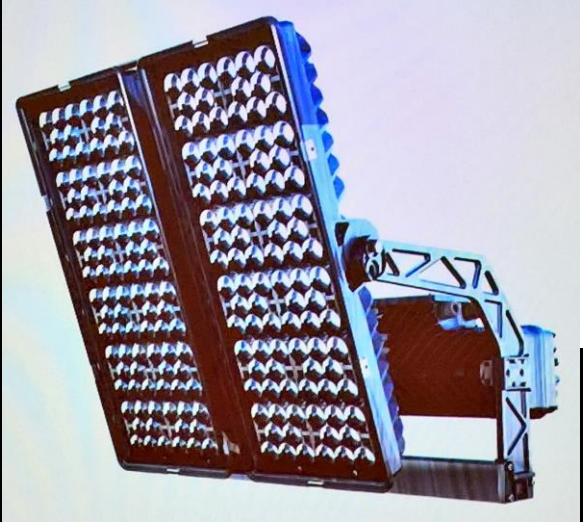


[7] Abschirmungen

Sind Abschirmungen vorzusehen?

- Zusätzliche Abschirmungen in spezifischen Problemfällen.
- Kap. 3.3.7

LIGHT SOURCES – FIXTURE LEVEL



EXAMPLE, SPORTS LIGHTING

Emission above horizon



EXAMPLE, SPORTS & STREET LIGHTING



STREET LIGHTS



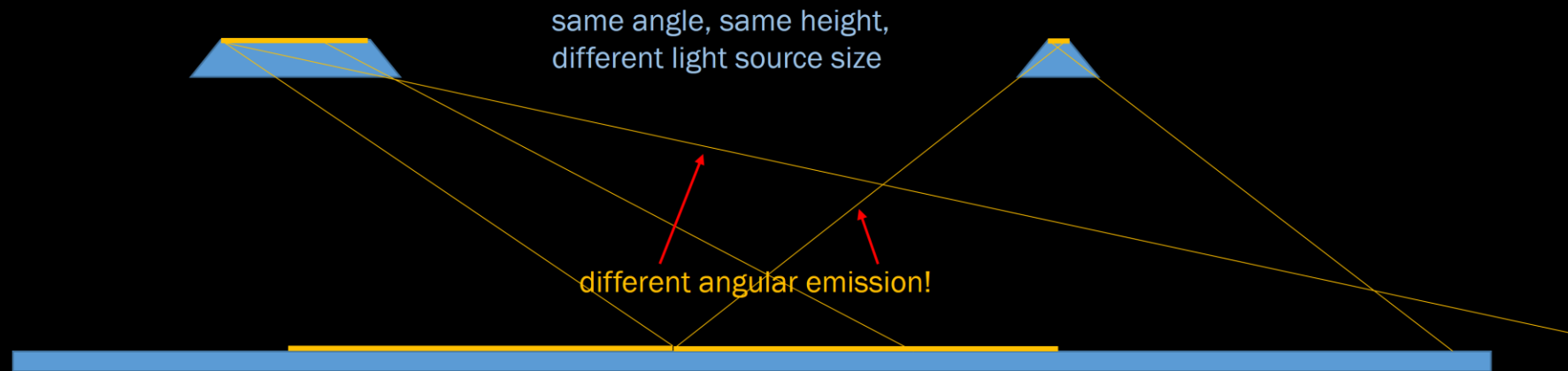
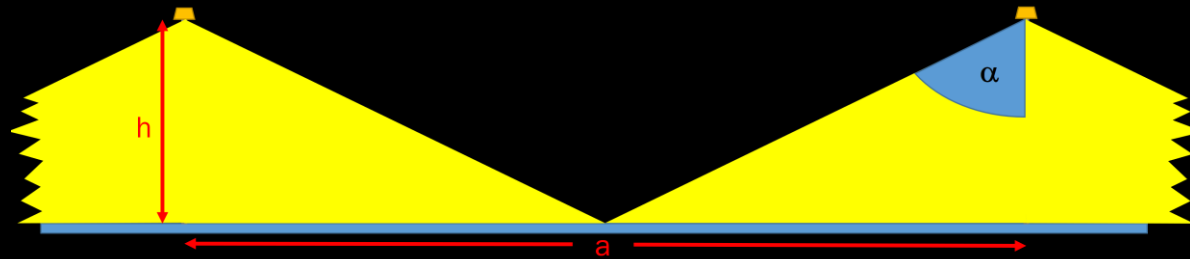
- Flat light output window, oriented horizontally: **no uplight!**
- no shields with respect to angles outside the target surface (road) to be illuminated
- -> part of the light is emitted above reasonable angles (longitudinal 75° - 90° ; transversal 20° - 90°)
-> light pollution,
->waste of energy,
-> obstacle for insects

WILL BETTER OPTICS HELP ?

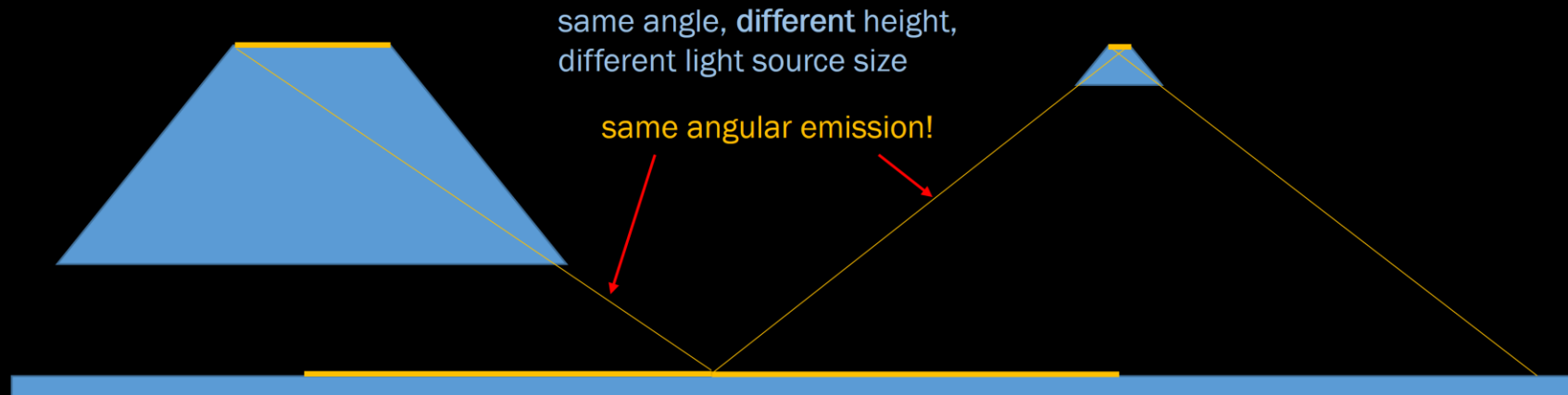
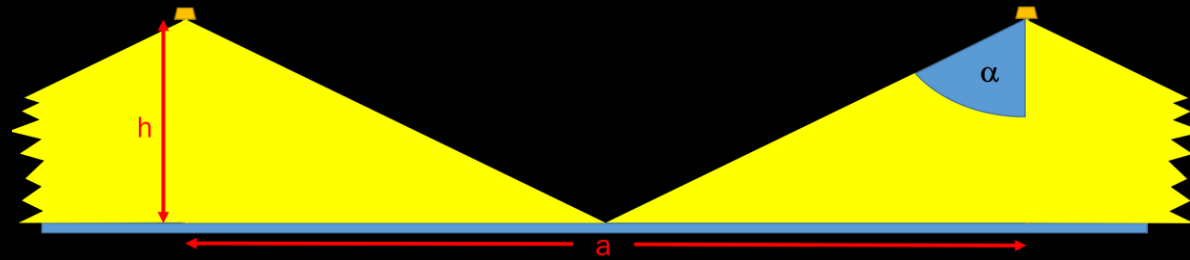


- optics tolerances & imperfections,
- cover glass,
- dirt
- -> scattering in undesired directions
- Standard optics will not improve much anymore.

CAN SHIELDS HELP ?

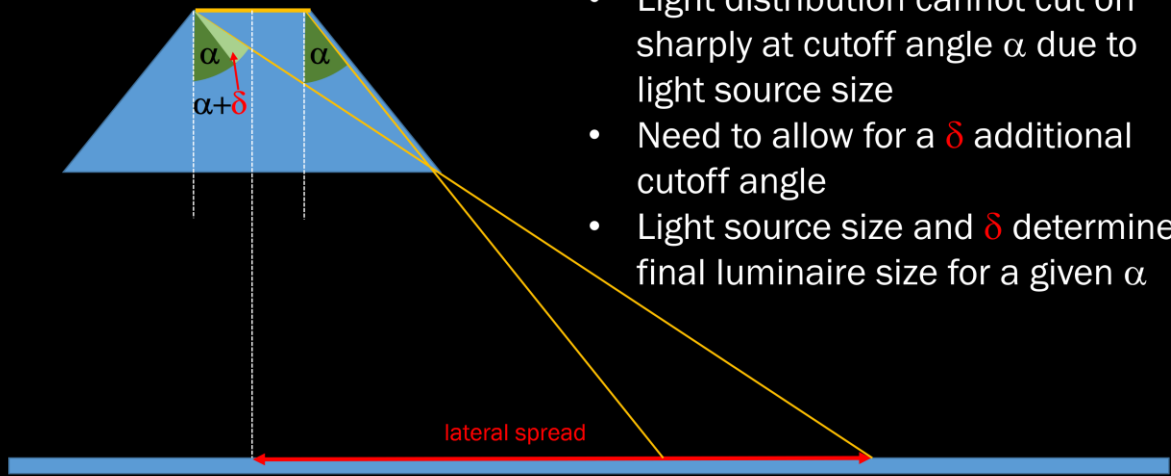


CAN SHIELDS HELP ?



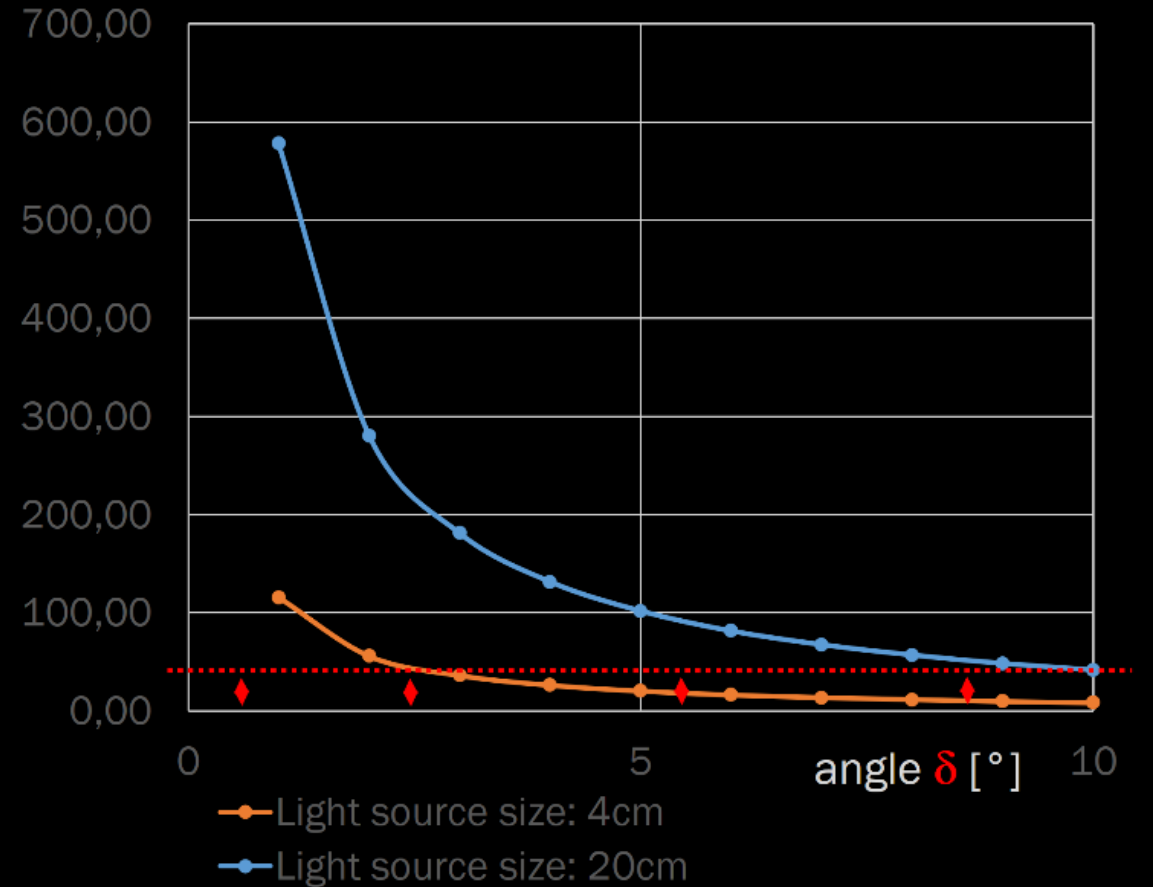
LUMINAIRE GEOMETRY

Geometrical relationship




- Light distribution cannot cut off sharply at cutoff angle α due to light source size
- Need to allow for a δ additional cutoff angle
- Light source size and δ determine final luminaire size for a given α

Luminaire size in direction of road [cm]



LEGAL BASIS

 Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Fedlex
The publication platform for federal law

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Home | **Classified Compilation** | Treaties

Home > Classified Compilation > 8 Health - Employment - Social security > 81 Health > 814.01 Federal Act of 7 October 1983 on the Protection of the Environment (Environmental Protection Act, EPA)

Additional information

This text is in force


Decision	October 7, 1983
In force	January 1, 1985
Source	AS 1984 1122
Publication language	DE FR IT RM EN

Tools

[Language comparison](#)

All versions of this law

● 01.01.2024	
● 01.01.2022	
● 01.01.2021	HTML PDF DOC
● 01.07.2020	PDF

814.01 [Expand all](#) | [Article overview](#) | [Collapse all](#) 

English is not an official language of the Swiss Confederation. This translation is provided for information purposes only and has no legal force.

Federal Act on the Protection of the Environment

(Environmental Protection Act, EPA)

of 7 October 1983 (Status as of 1 January 2021)


The Federal Assembly of the Swiss Confederation,
based on the Article 74 paragraphs 1 of the Federal Constitution^{1,2}
and having considered a Federal Council Dispatch dated 31 October 1979³,

decrees:

¹ [SR 101](#).

² Amended by No II 1 of the FA of 19 March 2010, in force since 1 Aug. 2010 ([AS 2010 3233](#); [BBI 2009 5435](#)).

³ [BBI 1979 III 749](#)

-  [Title 1 Principles and General Provisions](#)

LEGAL BASIS

¹ Air pollution, noise, vibrations and radiation are limited by measures taken at their source (limitation of emissions).

² Irrespective of the existing environmental pollution, as a precautionary measure emissions are limited as much as technology and operating conditions allow, provided that this is economically acceptable.

³ Emissions are limited more strictly if the effects are found or expected to be harmful or a nuisance, taking account of the existing level of environmental pollution.

- [Title 2 Pollution Control](#)
- [Chapter 1 Air Pollution, Noise, Vibrations and Radiation](#)
- [Section 1 Emissions](#)
- [Art. 11 Principles](#)

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³ Emissions are limited more strictly if the effects are found or expected to be harmful or a nuisance, taking account of the existing level of environmental pollution.

- [Art. 12 Limitation of emissions](#)

¹ Emissions are limited by issuing:

- maximum emission values;
- regulations on construction and equipment;
- traffic or operating regulations;
- regulations on the heat insulation of buildings;
- regulations on thermal and motor fuels.

² Limits are prescribed by ordinance or, in cases where an ordinance makes no such provision, by rulings based directly on this Act.

- [Section 2 Ambient Pollution Levels](#)
- [Art. 13 Ambient limit values](#)

¹ The Federal Council stipulates by ordinance the ambient limit values for assessing harmful effects or nuisances.

² In doing so, it also takes account of the effects of pollution levels on particularly sensitive groups such as children, the sick, the elderly and pregnant women.

- [Art. 14 Ambient limit values for air pollution](#)

The ambient limit values for air pollution must be set so that, in the light of current scientific knowledge and experience, ambient air pollution below these levels:

- does not endanger people, animals or plants, their biological communities and habitats;
- does not seriously affect the well-being of the population;
- does not damage buildings;
- does not harm soil fertility, vegetation or waters.

WHAT TO DO ?

- Need for light sources with (internal) sharp cutoff – LEDs (+ primary optics)
- But very small
- LED development is not exhaustive so far (efficiency, spectrum)
- Light emission characteristics equally important
- POSSIBILITIES:
 - microoptics
 - micro-/nanostructured conversion layers
 - photonic lattices
 - miniaturize light sources, increase luminance / minimize étendue
 - laser based lighting (LARP)?

BEST PRACTICE (right picture)

MARKET LEADER



OUR APPROACH



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Thank you for your attention!

[https://www.welt.de/wissenschaft/weltraum/article186607966/Milchstrasse-
-Unserer-Heimatgalaxie-steht-der-grosse-Crash-bevor.html](https://www.welt.de/wissenschaft/weltraum/article186607966/Milchstrasse-Unserer-Heimatgalaxie-steht-der-grosse-Crash-bevor.html)