

MINT trifft digitale Kompetenz(en)

Knut Neumann



1

Relevanz des Faches Informatik

Erscheint die Einführung von Informatik als Pflichtfach geboten?

2

Umfang des Faches Informatik

Ab wann wäre die Einführung von Information sinnvoll?

3

Informatik trifft Naturwissenschaften

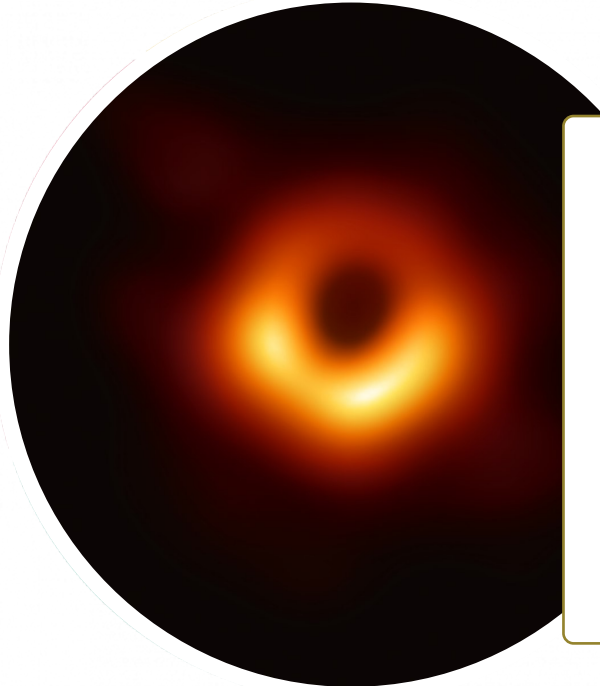
Welche Inhalte sollten im Zentrum stehen?

Digitale Kompetenzen

(Carretero Gomez, Vuorikari & Punie
(2017))



Digitale Kompetenzen in MINT



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CONFERENCE

First M87 Event Horizon Telescope Results. I. The Shadow of the Supermassive Black Hole

The Event Horizon Telescope Collaboration
Shinji Hada et al. (see full list of authors)
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ABSTRACT

When surrounded by a transparent emission region, black holes are expected to reveal a dark shadow caused by gravitational light bending and photon capture of the event horizon. To image and study this phenomenon, we have constructed the Event Horizon Telescope, a global very long baseline interferometry array observing at a wavelength of 1.3 mm. This allows us to measure the shadow-like image of the supermassive black hole residing in the center of the giant elliptical galaxy M87. We have used the central compact radio source as an approximate light emission size with a diameter of 2.2×10^3 km, which is comparable to the apparent event horizon in images with a flux ratio of 0.04. The emission ring is resolved using different observing and imaging schemes, with its diameter and width measured well over the different observation epochs on an 8-hour scale. Overall, the observed image is consistent with expectations for the shadow of a Kerr black hole as predicted by general relativity. The asymmetry in brightness in the ring can be explained in terms of relativistic beaming of the emission from electron-modified disk in the event horizon region.

We report the first observed black hole. We compare our image to an extensive library of ray-traced general-relativistic, magnetohydrodynamic simulations of black holes and derive a central mass of $M = 6.5 \pm 0.7^{+0.9}_{-0.6} M_{\odot}$. The relative orientation thus provides possible evidence for the presence of supermassive black holes in centers of galaxies and as the central engines of active galactic nuclei. They also present a new test to explore gravity in its most extreme field and as a new scale that was so far not accessible.

Key words: accretion, accretion disks – black hole physics – galaxies: active – galaxies: individual (M87) – galaxies: jets – gravitation

1. Introduction

Black holes are a fundamental prediction of the theory of general relativity (GR; Einstein 1915). A defining feature of black holes is their event horizon, a one-way causal boundary that separates from which not even light can escape (Schwarzschild 1916). The production of black holes is generic in GR (Penrose 1965), and many more sources other than stellar cores exist at the heart of fundamental questions in astrophysics with ongoing progress (Shapiro 1976; Chandra 2015).

Black holes are common in astrophysics and are found over a wide range of masses. Among the astrophysical black holes are stellar-mass black holes (StBHs; e.g., Bardeen & McKinnon 2004) and galactic-mass supermassive black holes (SMBHs; e.g., 2014). Supermassive black holes, with masses from millions to billions of solar masses, are thought to exist in the centers of nearly all galaxies (Gould 1965; Kormendy & Richstone 1995; Miyoshi et al. 2015), including in the vicinity of our Galaxy (Ghez et al. 1998; Gillessen et al. 2009; Gillessen et al. 2010) and in the nucleus of the nearby elliptical galaxy M87 (Richards et al. 2011; Walsh et al. 2013).

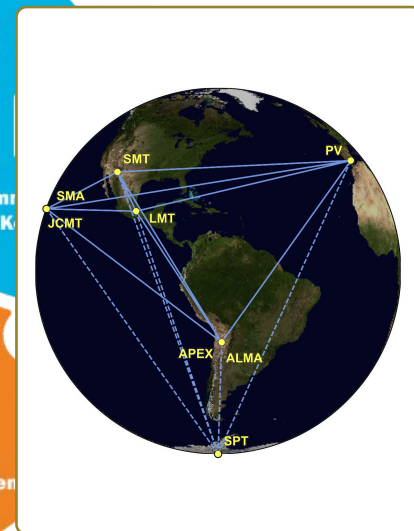
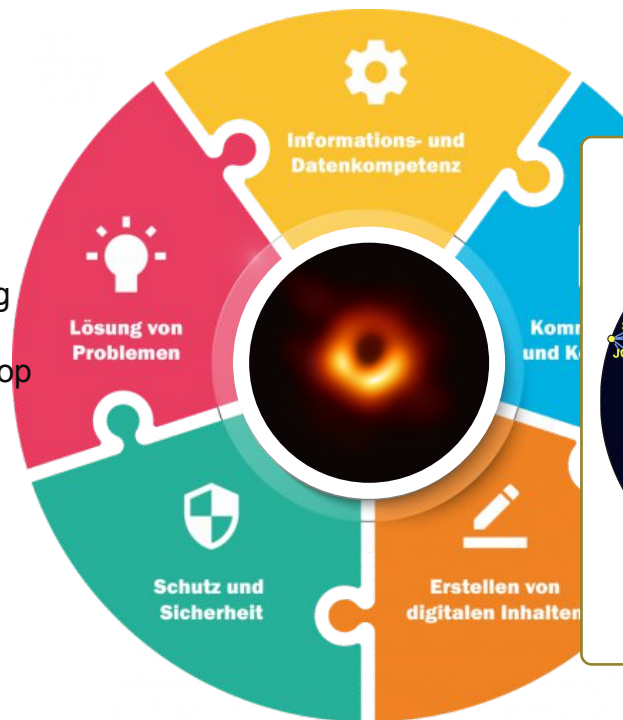
Active galactic nuclei (AGNs) are central bright regions that can ionize the entire nuclear population of their host galaxy. Some of these objects, quasars, are the most luminous steady sources in the universe (Schwartz 1963; Lynden-Bell 1995) and are thought to be powered by supermassive black holes accreting matter at very high rates through a geometrically thin, optically thick accretion disk (Shakura & Sunyaev 1973; Novak & Malhotra 1980). In contrast, most AGNs in the local universe, including the Galactic center and M87, are associated with supermassive black holes fed by hot, ionized accretion flows with much lower accretion rates (Galametz 1971; Narayan & Yi 1995; Hoadland & Begelman 1999; Yuan & Narayan 2014). In many AGNs, collimated relativistic jets are produced (Blandford & Payne 1982; Jones 1987; Jannelli et al. 2015). The central black hole contributes to the observed emission. These jets may be powered either by magnetic fields threading the event horizon, extracting the rotational energy from the black hole (Blandford & Znajek 1977), or from the accretion flow (Blandford & Payne 1982). The near-horizon emission from low-luminosity active galactic nuclei (LLAGNs) has been predicted by hydrodynamic models that predict iron-line emission (Fitzgerald 1976). This emission only be produced either in the accretion flow (Chen et al. 1995; Falcke et al. 1998), or from the innermost part of the accretion flow (Yuan et al. 2002).

When viewed from infinity, a nonrotating Schwarzschild (1916) black hole has a photon capture radius $R_{\text{pc}} = 2.5 r_g$, where $r_g = GM/c^2$ is the characteristic lengthscale of a black hole. The photon capture radius is larger than the Schwarzschild radius R_{sh} , the mark the event horizon of a nonrotating black hole. For a rotating black hole, the photon capture radius is $R_{\text{pc}} < R_{\text{sh}}$ and captured and ejected into the black hole (Illorri 1972); photons with $R_{\text{pc}} < R_{\text{sh}}$ escape to infinity. In the Kerr (1963) metric, which describes black holes with spin angular momentum, R_{pc} changes with the spin parameter a and is generally smaller than the Schwarzschild radius. In the dipole-dominant regime, and the black hole's outer surface is not necessarily circular.

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Digitale Kompetenzen in MINT

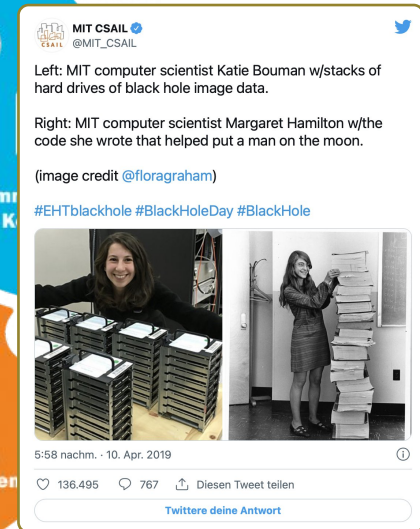
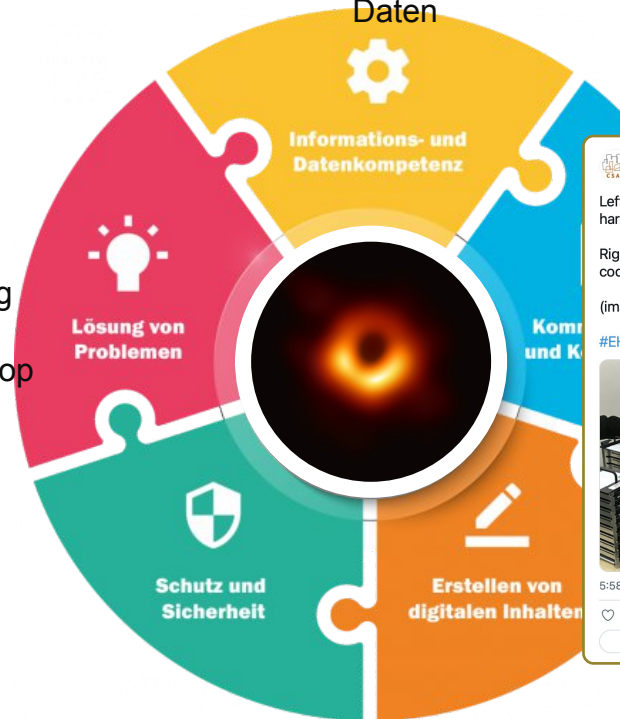
Umprogrammierung
ALMA-Teleskop zu
einem VLBI-Teleskop



Speicherung und Management
von 4.5 PB astronomischer
Daten

Digitale Kompetenzen in MINT

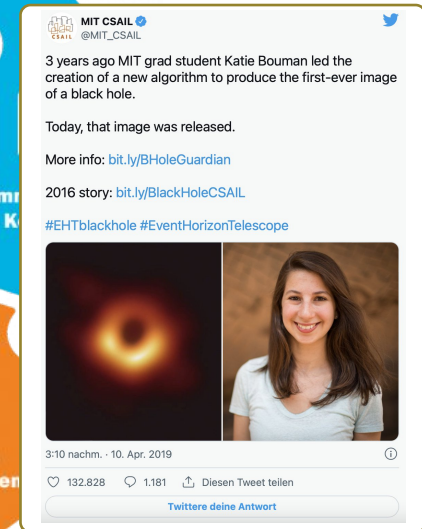
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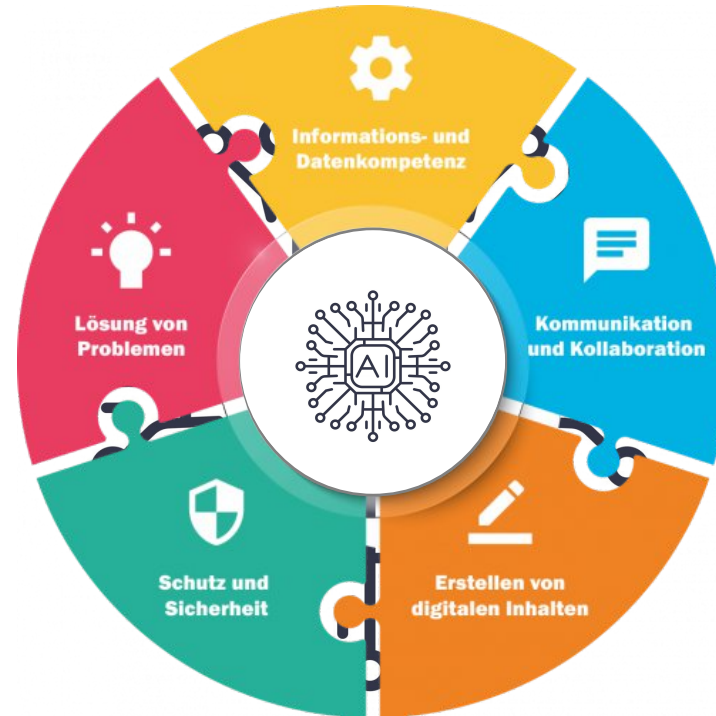
Digitale Kompetenzen in MINT

Umprogrammierung
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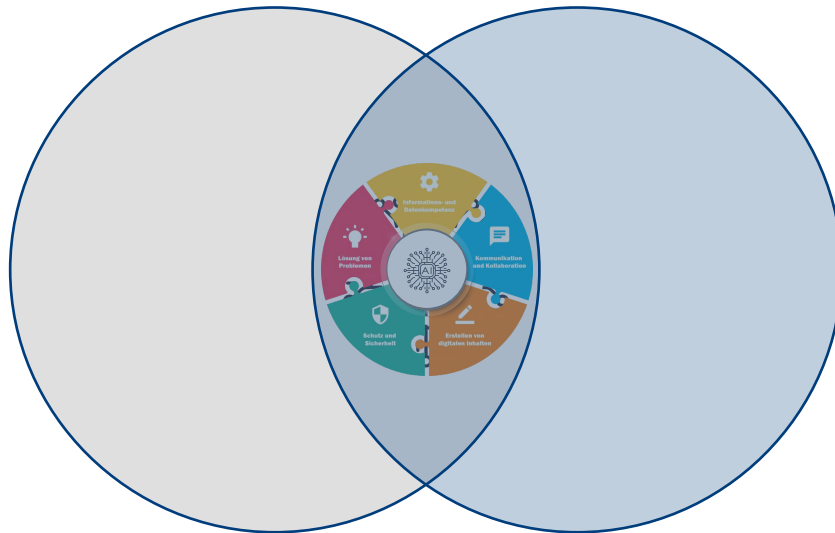
Entwicklung eines
Algorithmus zur
Konstruktion des
Bildes (eines
schwarzen Lochs)

Digitale Kompetenzen in MINT



Der Beitrag der Fächer zur Entwicklung digitaler Kompetenzen

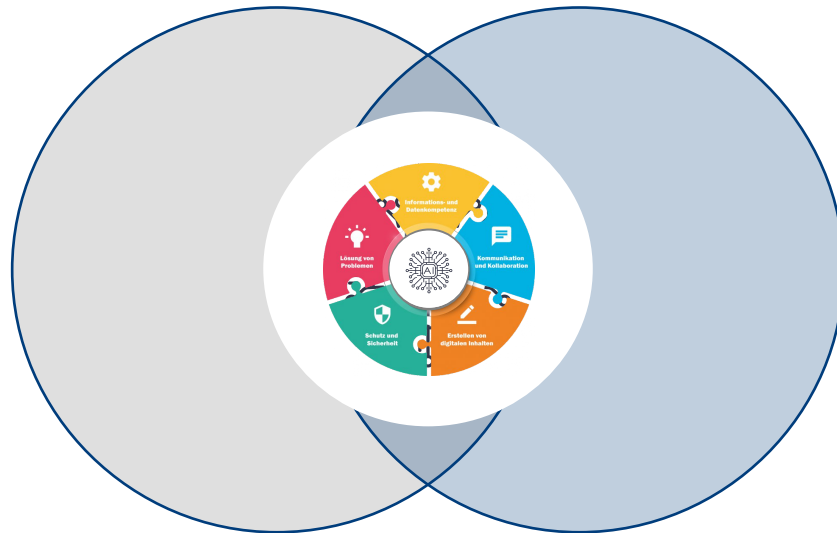
Informatik



Naturwissenschaften

Der Beitrag der Fächer zur Entwicklung digitaler Kompetenzen

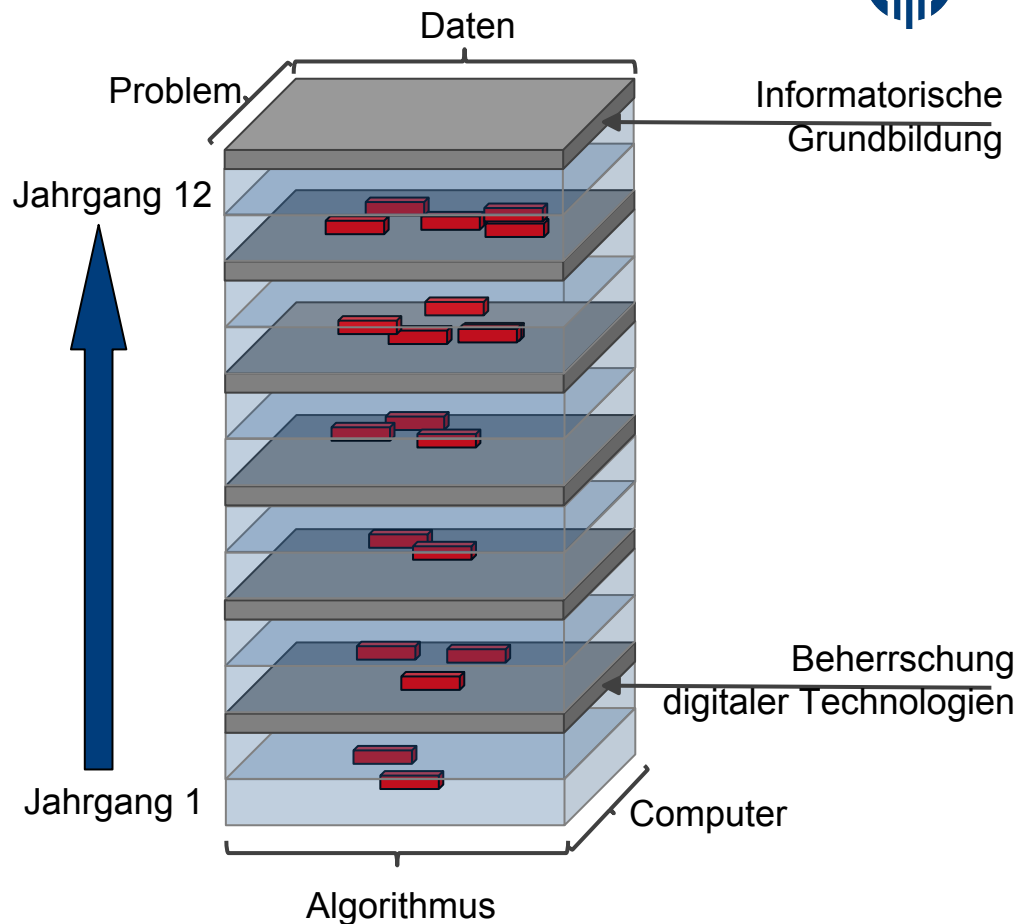
**Informatik
Wissen**



**Naturwissenschaften
Anwendung**

Entwicklung digitaler Kompetenzen

(vgl. Neumann et al., 2007;
Zendler & Spannagel, 2006)





1

Erscheint die Einführung von Informatik als Pflichtfach geboten?
JA – JA – und... JA

2

Ab wann wäre die Einführung von Information sinnvoll?
So früh wie möglich, mit Entwicklungsperspektive

3

Welche Inhalte sollten im Zentrum stehen?
Zentrale Konzepte des Faches und ... digitale Kompetenzen

Vielen Dank für Ihre Aufmerksamkeit!