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References

[1] G.A. Proca, Alexandre Proca. O*euvre Scientifique Publiée,* S.I.A.G., Rome, 1988.

[2] A. Calboreanu, *Rom. J. Phys.* **49** (2004) 3.

[3] http://www.th.physik.uni-frankfurt.de/~poenaru/PROCA/Proca.html (2005). D.N. Poenaru, *E-print, physics/0508195*, http://arXiv.org, 2005.

[4] W. Pauli, *Nobel lecture*, December 13, 1946.

[5] W. Pauli, *Rev. Mod. Phys.* **13** (1941) 213.

[6] C. P. Enz, *No time to be brief* (A scientific biography of Wolfgang Pauli), *Oxford University Press*, New York, 2004.

[7] L.-C. Tu, J. Luo, G.~T. Gillies, *Rep. Prog. Phys.* **68** (2005) 77.

[8] D. Levrett, A.S. Goldhaber, M.M. Nieto, *Phys. Rev. Lett.* **35** (1975) 1402. A.S. Goldhaber, M.M. Nieto, *Scientific American* **234** (1976) 86.

[9] C. Vuille, J. Ipser, J. Gallagher, "Einstein-Proca model, micro black holes, and naked singularities", *General Relativity and Gravitation*, 34 (2002) 689.

[10] R. Tomaschitz, *Physica A* **293** (2001) 247; *A* **335** (2004) 577; *Eur. Phys. J. D* **32** (2005) 241.

[11] W. Greiner, *Relativistic quantum mechanics*; W. Greiner and J. Reinhardt, *Field quantization*; W. Greiner and A. Schäfer, *Quantum chromodynamics*, Springer, Berlin, 2000, 1996, 1995, respectively.

[12] R. Scipioni, "Isomorphism between non-Riemannian gravity and Einstein-Proca-Weyl theories extended to a class of scalar gravity theories", *Class. Quantum Grav.,* **16** (1999) 2471.

[13] R. W. Tucker and C. Wang, C., "An Einstein-Proca-fluid model for dark matter gravitational interactions", *Nucl. Phys. B* - Proc. suppl., **57** (1997) 259.

[14] H. Belich, T. Costa-Soares, M. M. Ferreira Jr., J. A. Helay-Neto, "Classical solutions in a Lorentz violating scenario of Maxwell-Chern-Simons-Proca electrodynamics", *Eur. Phys. J. C* **42** (2005) 127.

Water from Heaven

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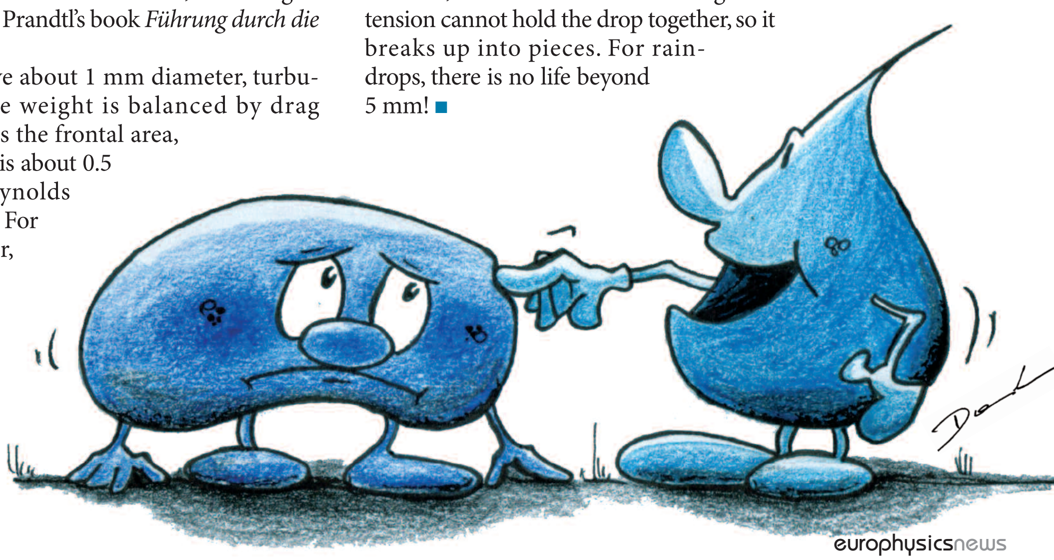
Large rain drops fall faster than small ones, that much is obvious for any physicist. But let's be a bit more precise. The terminal velocity follows from the balance between the weight of the drop and its air resistance. What exactly is the resistance of a drop falling through the atmosphere? We have to distinguish two regimes here. If the droplets are very small, like cloud droplets (or fog particles, if you wish), the Reynolds number is so small that Stokes' formula applies: the air resistance is proportional to viscosity, radius and velocity: $F = 6\pi\eta Rv$. For a typical cloud droplet having a radius of 0.01 mm, we find a terminal velocity of about 1 cm/s. That is very small indeed. But it goes up rapidly with size: since its weight is proportional to R^3 and the resistance only to R, the terminal velocity increases with the square of the size for such droplets. That applies to droplets up to about 0.1 mm in diameter, according to the handbooks (good old Ludwig Prandtl's book *Führung durch die Strömungslehre*, for example).

For ordinary raindrops, above about 1 mm diameter, turbulent flow dominates. Here the weight is balanced by drag $F_D = C_D\pi R^2.1/2\rho v^2$, where πR^2 is the frontal area, C_D is the drag coefficient, which is about 0.5 for a sphere at the relevant Reynolds numbers, and ρ the density of air. For a rain drop of 1 mm in diameter, we find a terminal velocity of 16 km/h. Note that in this regime the velocity is proportional to the square root of the diameter. Consequently, a 3 mm raindrop reaches 28 km/h. And so on, we would guess. Given the above, we may expect that for the biggest drops - 5 mm, say - the terminal velocity is well above 35 km/h.

Wrong! Something interesting happens, as already noticed by the German physicist, Philipp Lenard, a century ago. Using a vertical wind tunnel to balance the speed of the drop, he noticed that drops larger than about 3 mm diameter become deformed to the shape of a small pancake, and have a flat bottom. Consequently, their frontal area is larger than for spherical droplets having the same mass. As a result of the increased drag, the terminal velocity hardly increases any further: for raindrops of 4 and 5 mm it reaches an asymptotic value of about 29 km/h, which is practically the same speed as that already reached by the 3 mm drops.

And beyond 5 mm? As soon as the diameter reaches about 5.5 mm, the forces become so large that surface tension cannot hold the drop together, so it breaks up into pieces. For raindrops, there is no life beyond 5 mm! ■



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