abstract The pulse profiles of the accreting X-ray millisecond pulsar SAX J1808.4−3658 at different energies are studied. The two main emission components, the black body and the Comptonized tail that are clearly identified in the time-averaged spectrum, show strong variability with the first component lagging the second one. The observed variability can be explained if the emission is produced by Comptonization in a hot slab (radiative shock) of Thomson optical depth $\sim 0.3$–1 at the neutron star surface. The emission patterns of the black body and the Comptonized radiation are different: a “knife”– and a “fan”–like, respectively. 

We construct a detailed model of the X-ray production accounting for the Doppler boosting, relativistic aberration and gravitational light bending in the Schwarzschild spacetime. We present also accurate analytical formulae for computations of the light curves from rapidly rotating neutron stars using formalism recently developed by Beloborodov (2002). Our model reproduces well the pulse profiles at different energies simultaneously, corresponding phase lags, as well as the time-averaged spectrum. We constrain the compact star mass to be bounded between 1.2 and $1.6M_{\odot}$. By fitting the observed profiles, we determine the radius of the compact object to be $R \sim 11$ km if $M = 1.6M_{\odot}$, while for $M = 1.2M_{\odot}$ the best-fitting radius is $\sim 6.5$ km, indicating that the compact object in SAX J1808.4−3658 can be a strange star. We obtain a lower limit on the inclination of the system of 65.