Abstract

In the framework of this PhD thesis, the study of the distribution of an extended mass close to the super-massive black hole (SMBH) at the centre of our Galaxy is addressed using observational data and theoretical modelling. The main emphasize is on establishing a distinction between the fraction of dark mass present in the form of a black hole and that in an extended form. Despite the significant observational and theoretical progress in the understanding of SMBHs in the last ten years, the formation of SMBHs and the interplay with their host galaxy are still poorly understood. The work presented here extends our understanding of the dynamics in the vicinity of the SMBH. Already in 1974, it was proposed that the radio source Sgr A* could be a SMBH. With observations during the following years, it became more clear that the centre of our Galaxy hides an amount of dark mass close to 3×10^6 $M_\odot$. However, the strongest evidence for the existence of a SMBH, was only after it became possible to trace for the first time stellar orbits of fast moving stars, the so-called S-stars, around Sgr A*. This was achievable using the SHARP near-infrared speckle camera at la Silla in Chile as well as the near-infrared camera NAOS/CONICA at the Very Large Telescope (VLT) at Paranal in Chile. In collaboration with the near-infrared group at the Max-Planck-Institut for Extra-terrestrial Physics in Garching by Munich, I used the imaging data on the Galactic Centre to study the stellar distribution, and used proper motion and radial velocity data to study the motion of the S-stars at the Galactic Centre.

In order to investigate the distribution of mass around the black hole, in this work, stellar orbits are modelled assuming an extended mass potential, in addition to the potential of the black hole. I study the orbits in both Keplerian and non-Keplerian potentials. This is *the first study of this kind* combining observational data and theoretical modelling.

This work shows also the first approach where the mass-to-light ratio (M/L) is considered to be varying from the outer regions to the inner regions of the galaxy. From earlier dynamical studies on galaxy evolution, it is widely agreed upon the M/L increasing in the inner regions of a galaxy. This implies that there could exist an additional quantity of hidden mass close to the centre. Here, I study explicitely possible candidates for this hidden component - faint, low-mass stars and heavier compact remnants.

In practice, meaningful analysis is only possible on the star S2 which shows the shortest orbital period and therefore the most complete orbit of all other S-stars. A 4^{th}-order Hermite integrator, which I optimized for this study, is used to model the S2-orbit in response to the SMBH potential as well as an additional extended mass distribution. A grid method is implemented to the Hermite scheme to fit the S2 orbit to the positional and velocity data available from the year 1992 till 2003. I was able to confirm the position of the black hole candidate Sgr A*, to determine an upper limit on the total amount of mass that could be present in the central 20 mpc and extended into the outer regions of the central stellar cluster, as well as to deduce an upper limit on the M/L. This work leads to the results that the total central dark mass is not necessarily confined entirely in a SMBH. A fraction $\lesssim 20\%$ of this mass could be present

in an extended distribution. Testing different distributions for this extended mass component, it turned out that the present data do not suffice to discriminate between the different potentials.

In order to study the constituents of the possible extended dark component, I investigate the K-band luminosity function (KLF) of the observed stellar cluster.

The result is that, the extended mass cannot be formed only by faint, low-mass stars. The presence of stellar black holes and neutron stars is required in order to account for the possible extended mass fraction in the centre of the Milky Way. Furthermore, such a cluster of stellar remnants analysed in an approximative analytical form, is found to be stable.