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The Distance to the Center of the Galaxy: the Current State-of-the-Art in Measuring R_0

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Abstract. The current situation regarding the problem of the Sun–Galactic center distance, R_0, is discussed. A new three-dimensional classification of R_0 measurements is suggested. Despite the importance of certain of recent results reviewed, overall progress in solving the problem of R_0 remains slow. At this time a "best value" for R_0, based upon 65 original R_0 estimates from 57 works published since 1974, is 7.9 ± 0.2 kpc.

1. Introduction

The value of the Galactic center distance R_0 has a great impact on astronomy and astrophysics (see, e.g., Reid 1993, hereafter R93). Because of this, following the first measurement of R_0 by Harlow Shapley (1918) astronomers have consistently made considerable effort to determine this fundamental parameter. Besides, such studies are stimulated by an "inconstancy" of the constant R_0. Table 1 gives an idea of the "evolution" of R_0 value. Till the eighties of the XXth century, even the "adopted" ("standard", "mean", "best", "best estimate") value for R_0 was grossly changed. Later this variation became closer, and yet the accuracy of the adopted value remained low as did rather wide the scatter of individual estimates of R_0.

Table 1. Evolution of "best value" and individual estimates for R_0

Source		R_0 (kpc)	Covered range of years
Shapley	1918	$\approx$13	
Baade	1951	8.7	
Oort-Baade value (see, e.g., Woolley 1963)	1954	8.2	
IAU standard	1964	10	
de Vaucouleurs	1983	8.5 ± 0.5	1974–1982
Kerr & Lynden-Bell	1986	8.54 ± 1.1	1974–1986
→ IAU standard	1986	8.5	
Feast	1987	$7.8 \pm \sim 0.8$	1974–1986
Reid	1989	7.7 ± 0.7	1972–1986
Reid	1993	8.0 ± 0.5	1972–1993
Individual estimates (Reid 1993)		6.2–10.4	1972–1993
Individual estimates (this paper)		6.5–8.7	1994–2003

After the last comprehensive review of the problem by R93, a number of advances has been made: i) *new luminosity calibrations* of traditional distance indicators and suggestions of *new distance indicators*, both from the *Hipparcos* astrometric catalogue and additional data; ii) new *absolute* (i.e., not using luminosity calibrations) estimates of R_0; iii) efforts towards *perfecting methods* of deriving R_0; iv) updated relative (i.e., using calibrations) estimates of R_0 from *new data*, more numerous and/or more reliable. In this paper, we review the current status of research on the problem of R_0, emphasizing the results published since the R93 analysis. We suggest a new classification of R_0 measurements and, with it, compute a current "best value" for R_0.

2. Sources of Errors in Estimates of R_0

In almost all cases, measuring R_0 involves two constituent problems:

Problem 1. To obtain the heliocentric distances, which may be called the "*reference distances*" (RDs) in measuring R_0, and also other data (velocities, metallicities etc.) for some Galactic objects, or "reference objects" (ROs).

Problem 2. To derive *a value of R_0 from an analysis of reference distances* and other data.

Any estimate of R_0 is always expressed in the overall scale of accepted RDs; consequently, an error in the scale biases the R_0 estimate. Except that a *proper method of deriving* R_0 (i.e., a method of solving Problem 2) also introduces systematic errors of its own. If for no other reason than this, a distinction needs to be drawn between these two problems.

From this simple reasoning, *objective* sources of errors in an estimate of R_0 can be broken down into the following categories:

I. *Systematic errors*:

I.1. **Systematic errors in reference distances** owing to a) errors in the distance scale(s), or b) fallacies in the absolute method of estimating distances.

I.2. Systematic errors in other observational data.

I.3. **Fallacies in the proper method of deriving an estimate of $\mathbf{R_0}$** from accepted RDs and other input data.

II. *Random errors*:

II.1. Random errors in observational data.

II.2. A statistical uncertainty of the proper method of deriving an estimate of R_0 from accepted observational data.

In addition, Reid (1989, 1993) found clear evidence for a *subjective* (psychological) source of errors—so called the "**bandwagon effect**", i.e., a tendency for new published R_0 values to cluster around the "correct answer" (a current "accepted value" of R_0). A possibility for easy "correction" of a "wrong" R_0 estimate results from uncertainties in the distance scale(s), systematic errors in the proper method, and an arbitrariness in the procedure of analyzing data. Then the systematic variations of *rescaled* R_0 estimates with time in R93 actually give an evaluation of the impact of two factors last named—$\sim$1.5 kpc! By this is meant that perfecting proper methods of deriving R_0 estimates, which has not yet received due attention, is essential for solving the problem of R_0 as are obtaining new observational data and new calibrations of distance scales, elaborating new proper methods, and studying the internal nature of ROs.

Besides, it is well bear in mind that the term "center of the Galaxy" implies different definitions in different methods: i) a *central singularity of the spatial distribution* of some luminous matter or a *"central" object* (Sgr A*, IRS16, Sgr B2, etc.); ii) a *dynamic center*, i.e., a barycenter; and iii) other, more peculiar, definitions. Conceivable discrepancies between the positions of different "centers" (Blitz 1994) can be another systematic factor in the problem of R_0.

3. Classification of R_0 Measurements

A classification of R_0 measurements, which correctly reflects at least the main specific features of *diverse* sources of errors in different approaches and a non-uniqueness of the term "Galactic center", would have to be multi-dimensional. Such a classification could be useful in revealing probable sources of errors in R_0 measurements of a given type and hence in perfecting these measurements, as well as in deriving a "best value" for R_0 with due regard for statistical and systematic uncertainties.

We classify measurements of R_0 according to *three* independent features:

I. According to **the type of proper method of measuring** R_0, i.e., the type of fundamental technique for analyzing the RDs and other input data:

I.1. *Spatial methods*: Shapley's and Baade's methods, cone of avoidance, drop in distribution along the X-axis (Harris 1980), central object (pioneered by Moran et al. 1987). In all these methods, by the Galactic center is implied a spatial singularity, the data analyzed are on the spatial distribution of ROs, the main troubles are selection and statistical effects.

I.2. *Kinematic methods.* Here, by the Galactic center is meant a barycenter (a singularity in the phase space), the data are on the phase distribution (spatial coordinates and velocities) of ROs, the main troubles are inadequacies in the accepted kinematic model and in fitting assumptions. These methods are widely diversified. They may be subdivided in respect to at least four independent features: the composition of the kinematic model in terms of considering noncircular motions, the functional forms representing the Galactic circular rotation law, the fitting technique for deriving R_0, and the way of allowing for an uncertainty in RDs (see details in Nikiforov 2003, hereafter N03).

I.3. *Dynamic methods* are based on comparing independent data for the space and phase distributions, i.e., for the local density and non-local rotation law (e.g., Olling & Merrifield 1998). Here, it is assumed that the barycenter coincides with the spatial singularity. These methods combine the troubles of both spatial and kinematic methods, and, again, have a specific source of systematics—a dependence of R_0 value on *numerous* added assumptions of varied Galactic characteristics. Hence dynamic methods are obviously exceeded in total reliability by spatial and kinematic ones, all other things being equal.

I.4. *Non-phase methods* by Belikov & Syrovoj (1977) and by Surdin (1980). The data are on the distribution of ROs in a non-phase space (i.e., which is not a subset of the phase one), by the Galactic center is meant a singularity in this space. Such a space combines the configuration one (spatial coordinates) with an RO characteristic different from the velocity (e.g., the metallicity). The main troubles are inadequacies in suppositions as to this characteristic's behaviour and in fitting assumptions; this reminds of systematics of kinematic methods.

II. According to **the way of finding the reference distances**:

II.1. *Empirical R_0 measurements* rely on empirical determinations of RDs: a) *relative* measurements, based on distance scales eventually using luminosity calibrations from local objects; b) *absolute* (geometrical) measurements, based on RDs found without luminosity calibrations: from a modeling systematic motions in a shell of RO (e.g., Moran et al. 1987), by the statistical parallax method (e.g., Huterer, Sasselov, & Schechter 1995; Genzel et al. 2000; Eisenhauer et al. 2003), by comparing the angular radius of RO shell with the absolute one found from the phase lag (e.g., Honma & Sofue 1996), from the "orbiting binary" technique for the star S2 and source Sgr A* (Eisenhauer et al. 2003).

II.2. *Theoretical R_0 measurements* are uncommon. They rely on determinations of RDs from theoretical constraints: the Eddington limit and a theoretical maximum luminosity of planetary nebulae (see refs in R93).

III. According to **the type of reference objects**, R_0 measurements are from: globular clusters; RR Lyrae variables; Mira variables; classical Cepheids; OB stars; H II regions and molecular clouds observed in CO; open clusters; molecular clouds observed in OH; stars at the main-sequence turn-off; masers at the periphery of newly-formed, massive stars; OH/IR stars; planetary nebulae; X-ray sources. Again, new RO types are recently suggested: the centroid of K and M giants in the Galactic bulge (Huterer et al. 1995); red clump stars (Paczyński & Stanek 1998); δ Scuti stars (Morgan, Simet, & Bargenquast 1998); red supergiants (Glushkova et al. 1998); the central star cluster (Genzel et al. 2000); the compact radio source Sgr A* (Eisenhauer et al. 2003).

For details of some classes of R_0 measurements and for corresponding refs see Feast (1987) and R93. More details of this classification as a whole and of individual classes are available in N03.

4. Recent Results

This section reviews, in terms introduced, only papers published since 1994. Most of earlier papers were covered by Feast (1987) and R93 (see also N03).

4.1. Perfecting Methods

Developing *Shapley's method*, Rastorguev et al. (1994) performed a modeling the spatial distribution of globular clusters by the *maximum likelihood method*, taking into account selection effects. Yet their technique can underestimate an R_0 value if the interstellar dust exhibits a prominent concentration toward the Galactic center, and not just toward the Galactic plane.

Kinematic methods. Pont, Mayor, & Burki (1994) applied the *two-dimensional χ^2 fitting*, considering an uncertainty in distance moduli, to model the radial velocity field. This technique removes the bias of ordinary least squares, and yet it causes an R_0 estimate to depend on assumptions of velocity dispersion and of errors in distance moduli.

Nikiforov & Petrovskaya (1994) and Nikiforov (1999a,b) suggested and used a technique for constructing *optimally smooth rotation models*. Metzger, Caldwell, & Schechter (1998) tried to introduce an *elliptical distortion component* into the kinematic model. However, the problem of distinguishing between a tiny structure in the rotation law and perturbations due to streaming motions, with commonly used data on only a "local" galactocentric sector, remains unsolved. No R_0 estimate with regard to spiral wave perturbations appeared after Byl & Ovenden (1978). An attempt to take into account a *difference between HI and RO rotations curves*, likely caused by streaming motions, was done by Nikiforov (2000).

Dynamic methods. Olling & Merrifield (1998) considered the *gaseous component* in dynamic modeling, yet this refining does not cure the main troubles of dynamic methods (see section 3).

4.2. New Types of Reference Objects in Relative Measuring R_0

Red clump stars. Using them as new distance indicators was proposed by Paczyński & Stanek (1998). Large number of these stars both in the Solar neighborhood (~1000 in the *Hipparcos* catalogue) and in Baade's window (~10000) gives a high precision of the luminosity calibration ($\pm\sim0\overset{m}{.}02$–$0\overset{m}{.}03$) as well as of R_0 estimates by Baade's method (±~0.1 kpc, see refs in Table 2). Problems with the metallicity dependence for red clump stars (see Reid 1999, hereafter R99, and refs within) appear not to be more difficult than similar problems for traditional distance indicators (Stanek et al. 2000). To re-normalize the R_0 estimates from such ROs, we adopt a calibration for the Baade's window clump, $M_I(\mathrm{RC}) = -0.24 \pm 0.15$ at $[\mathrm{Fe/H}]_{\mathrm{BW}} = -0.15$ (see refs in N03).

δ Scuti stars are fainter variables as against RR Lyrae stars. A possibility to take the high-amplitude δ Scuti stars as ROs in Baade's method arose only recently (Morgan et al. 1998; McNamara et al. 2000) from the publications of the OGLE dark matter survey and *Hipparcos* catalogue. There appears to be more efficiently to use only the metal-strong variables (McNamara et al. 2000). We adopt $M_V(\delta\ \mathrm{Sct}) = -3.725 \log P - 1.933$, P is the variable's period, with an RDs' contribution of $\sigma_{\mathrm{RD}} = 0\overset{m}{.}15$ to the R_0 error budget (see N03).

Red supergiants, used by Glushkova et al. (1998) in a kinematic method, can be promising ROs due to a good accuracy of their distances and γ-velocities.

4.3. New Luminosity Calibrations for Traditional Reference Objects

The publication of the *Hipparcos* catalogue has greatly stimulated studies in the recalibration of distance indicators. The following in this subsection is a short summary of results from analyses of *Hipparcos* and other recent data.

RR Lyrae variables. Faint absolute magnitudes were confirmed at least for the local RR Lyraes: $\langle M_V(\mathrm{RR})\rangle \sim 0\overset{m}{.}75 \pm 0\overset{m}{.}15$ at $[\mathrm{Fe/H}] = -1.3$ (cf. R93 and R99, for more recent refs see N03). The problem of the metallicity dependence of $M_V(\mathrm{RR})$, like the suggested problem of a mismatch between the field and cluster calibrations, remains unresolved (R99).

Globular clusters. The MS-fitting to *Hipparcos* subdwarf data points to an average *increase* of $0\overset{m}{.}2$–$0\overset{m}{.}3$ in distance moduli as compared to Harris' (1996) $M_V(\mathrm{RR})$-based scale (R99; Carretta et al. 2000; N03). However, astrometric methods and the comparison with local white dwarfs lead to values of $M_V(\mathrm{HB})$ $0\overset{m}{.}1$–$0\overset{m}{.}2$ fainter than the subdwarf fitting (Carretta et al. 2000; N03). Therefore returning to the "canonical" (brighter) calibration, $M_V(\mathrm{HB}) = 0\overset{m}{.}6$ at $[\mathrm{Fe/H}] = -1.3$, seems to be most cautious at present. Here, the relation $M_V(\mathrm{HB}) = 0.2[\mathrm{Fe/H}] + 0.86$ and a value of $\sigma_{\mathrm{RD}} = 0\overset{m}{.}15$ were adopted (see N03).

Table 2. Recent relative estimates for R_0

Source	Method(s)[a]: Reference Objects	R_0 (kpc)	Comments
		Spatial measurements:	
Rastorguev et al. (1994)	Spatial modeling: globular clusters	(7 ± 0.5) 7.3 ± 0.55	$M_V(\mathrm{RR}) = 0.38[\mathrm{m/H}] + 1.32$, $M_V(\mathrm{HB}) = 0.6$
Layden et al. (1996)	B: RR Lyrae stars	7.6 ± 0.4	$M_V(\mathrm{RR}) = 0.15[\mathrm{Fe/H}] + 0.95$
Morgan et al. (1998)	B: δ Scuti stars	(7.6 ± 0.35^b) 7.7 ± 0.4	$M_V(\delta\ \mathrm{Sct}) = -3.73 \log P - 1.91$
Paczyński & Stanek (1998)	B: red clump stars	(8.4 ± 0.2)	$M_I(\mathrm{RC}) = -0.279$. Revised by Stanek et al. (2000)
Udalski (1998)	B: RR Lyrae stars	(8.1 ± 0.25) 8.4 ± 0.3	$M_V(\mathrm{RR}) = 0.18[\mathrm{Fe/H}] + 1.06$
Alves (2000)	B: red clump stars	(8.24 ± 0.42) 8.28 ± 0.42	$M_K(\mathrm{RC}) = -1.61$ $[M_I(\mathrm{RC}) = -0.23]$
McNamara et al. (2000)	B: δ Scuti stars B: RR Lyrae stars	7.86 ± 0.3^b (7.79 ± 0.08) 7.10 ± 0.07	$M_V(\delta\ \mathrm{Sct}) = -3.725 \log P - 1.93$ $M_V(\mathrm{RR}) = 0.55$ at $[\mathrm{Fe/H}] = -1.46$
Stanek et al. (2000)	B: red clump stars	(8.67 ± 0.1) 8.72 ± 0.1	$M_I(\mathrm{RC}) = -0.227$
Gould et al. (2001)	B: red clump stars	(8.63 ± 0.12) 8.60 ± 0.12	$M_I(\mathrm{RC}) = -0.247$ at $[\mathrm{Fe/H}] = -0.15$
		Kinematic measurements:	
Nikiforov & Petrovskaya (1994)	HI: H II regions	(7.5 ± 1.0)	Revised by Nikiforov (2000)
Pont et al. (1994)	MR: clas. Cepheids	(8.09 ± 0.30) 8.20 ± 0.30	$(m-M)_0^{\mathrm{LMC}} = 18^{\mathrm{m}}_{.}47$
Dambis et al. (1995)	MR: clas. Cepheids	(7.1 ± 0.5) 7.4 ± 0.5	$(m-M)_0^{\mathrm{LMC}} = 18^{\mathrm{m}}_{.}4^b$
Glushkova et al. (1998)	MR: 3 types of ROs	(7.3 ± 0.3)	Kholopov's ZAMS
Metzger et al. (1998)	MR: clas. Cepheids	7.66 ± 0.32	$(m-M)_0^{\mathrm{LMC}} = 18^{\mathrm{m}}_{.}50$
Nikiforov (1999b, 2000)	MR, HI: CO clouds	8.2 ± 0.7	
		Dynamic measurements:	
Olling & Merrifield (1998)	Comparing dynamic model with Galactic constants	(7.1 ± 0.4)	Assumptions of Oort's A and B constants, of Galactic dynamic model, of $-B/(A-B)$ etc.
		Non-phase measurements:	
Surdin & Feoktistov (1999)	Surdin's (1980): globular clusters	(8.6 ± 1.0) 9.2 ± 1.1	$M_V(\mathrm{RR}) = 0.2[\mathrm{Fe/H}] + 1.00$. See Surdin (1999)

[a] B = Baade's, MR = modeling rotation of the Galaxy, HI = comparison with H I.
[b] See details in N03.

Mira variables. We adopt the relation $M_K = 0.84 - 3.47 \log P$ with the zero-point from the *Hipparcos* parallaxes of local Miras (Whitelock & Feast 2000), independent on other calibrations. It is only slightly brighter than the pre-Hipparcos PL(K) relation (see N03). A value of σ_{RD} is also about $0^{\mathrm{m}}_{.}15$.

Classical Cepheids. Analyses of *Hipparcos* and additional data yielded contradictory results—from an *increase* of distance scales, so that an LMC distance module of $(m-M)_0^{\mathrm{LMC}} \sim 18^{\mathrm{m}}_{.}6 \div 18^{\mathrm{m}}_{.}7$ is derived from Cepheids (Feast et al.), to a *decrease* of distance scales, so that $(m-M)_0^{\mathrm{LMC}} \lesssim 18^{\mathrm{m}}_{.}4$ (Rastorguev et al.); see discussions and refs in R99 and N03. Thus the old calibration, $(m-M)_0^{\mathrm{LMC}} = 18^{\mathrm{m}}_{.}5$, with $\sigma_{\mathrm{RD}} = 0^{\mathrm{m}}_{.}2$, seems to be a good compromise today. (That is not adopting some LMC distance; a value of $(m-M)_0^{\mathrm{LMC}}$ is used here only to compare varied distance scales for Cepheids.)

OB stars. No significant correction was obtained for main-sequence stars, but a *decrease* of $\sim 0\overset{\mathrm{m}}{.}3$ in distance moduli was confirmed for *giants and supergiants* (see R99 and N03). Here, a correction of $-0\overset{\mathrm{m}}{.}15$ and a value of $\sigma_{\mathrm{RD}} = 0\overset{\mathrm{m}}{.}5$ were adopted for R_0 estimates from OB stars (see N03).

Open clusters. On the average, previous distances were confirmed—small corrections of opposite signs were obtained for different scales (see R99 and N03).

4.4. New Absolute Measurements of R_0

All *spatial* absolute R_0 estimates were obtained by the "central object method" in which a distance to a sole RO, assumed to be in the very center of the Galaxy, is taken as a value of R_0 without any further handling. In recent studies, the statistical parallax method was used to derive an absolute RD—by Huterer et al. (1995) for the centroid of K and M giants in the Galactic bulge, by Genzel et al. (2000) and Eisenhauer et al. (2003) for the central (within $10''$) star cluster. Unfortunately, this method is rather uncertain, even statistically (see Table 3).

A *kinematic* estimate of R_0 based on absolute RDs for OH/IR stars from comparing their shell angular radii with phase lags (Honma & Sofue 1996) is also not very accurate, mainly due to a limited number of ROs and systematic errors of the kinematic method applied.

Against this background, the very recent estimate (formally spatial) by Eisenhauer et al. (2003), $R_0 = 7.94 \pm 0.42$ kpc, with the absolute RD derived from a modeling the motion of the star S2 orbiting the massive black hole and compact radio source Sgr A*, is undoubtedly a major achievement.

Table 3. Recent absolute estimates for R_0

Source	Method of Estimating R_0[a]: Reference Object(s)	Method of Estimating RD(s)	R_0 (kpc)
	Spatial measurements:		
Huterer et al. (1995)	C: centroid of K and M giants	Statistical parallax	8.21 ± 0.98
Genzel et al. (2000), Eisenhauer et al. (2003)	C: central stellar cluster (within $10'' = 0.5$ pc)	Statistical parallax	7.2 ± 0.9
Eisenhauer et al. (2003)	C: S2/Sgr A*	Orbiting binary	7.94 ± 0.42
	Kinematic measurements:		
Honma & Sofue (1996)	HI: OH/IR stars	Comparing angular radius with phase lag	7.7 ± 0.8[b]

[a]C = "central object method", HI = comparison with H I.
[b]See details in N03.

4.5. Traditional Reference Objects and Methods: Updated Results

A number of recent relative R_0 estimates was derived using *renewed observational data* on ROs, while by traditional methods and from ROs of traditional types.

In this class of results, among *spatial* methods the *Baade's* one alone was recently taken (Layden et al. 1996; Udalski 1998; McNamara et al. 2000); only the RR Lyrae variables, mainly in Baade's Window, were used as ROs. *Kinematic* methods were applied by Dambis, Mel'nik, & Rastorguev (1995) to classical Cepheids and by Glushkova et al. (1998) to a combined sample of classical

Table 4. "Best values" for R_0 from different groups of R_0 estimates

Covered range of years	All estimates R_0	$N_{\rm est}$ $N_{\rm pap}$	Relative estimates R_0	$N_{\rm est}$ $N_{\rm pap}$	Absolute estimates R_0	$N_{\rm est}$ $N_{\rm pap}$
1974–1993	7.85 ± 0.24	41 37	7.98 ± 0.24	35 31	7.61 ± 0.68	4 4
1994–2003	7.89 ± 0.19	24 20	7.93 ± 0.23	19 16	7.78 ± 0.33	5 4
1974–2003	$\mathbf{7.90 \pm 0.17}$	65 57	8.03 ± 0.20	54 47	7.73 ± 0.31	9 8

Cepheids, open clusters, and red supergiants. Surdin & Feoktistov (see Surdin 1999) revised, using the catalogue of globular cluster by Harris (1996), a value of R_0 obtained by one of *non-phase* methods (Surdin 1980).

5. A Current "Best Value" for R_0

Tables 2 and 3 list recent R_0 estimates, relative and absolute respectively. Relative estimates of R_0 were rescaled according to the adopted calibrations (see sections 4.2 and 4.3); original R_0 values are given in parentheses. In Table 2, only statistical errors in R_0 are presented. In Table 3, R_0 errors reflect all statistical uncertainties and systematic errors in RDs (if given in papers).

To try to account for varied sources of errors and covariances among different R_0 estimates, the rescaled R_0 values were averaged with weights in four steps: over homogeneous groups of R_0 estimates (having the same classes of method, of RDs, and of ROs), over all calibration groups and over independent ones, and the final averaging (see N03). Some categories of unreliable R_0 estimates (e.g., dynamic), the estimates from combined samples of ROs, and the revised results were not used in averaging (N03). The R_0 values, taken for this procedure, are plotted versus publication year in Figure 1. The resulting "best R_0 values" for some groups of R_0 estimates ($N_{\rm est}$ is the number of estimates, $N_{\rm pap}$ is the number of papers) are presented in Table 4.

With the adopted calibrations, variations of R_0 with time (Figure 1) are not so high as in R93, due in part to rescaling for R_0 values from OB stars in this review, contrary to R93. Differences between R_0 estimates obtained before 1994 and more recent ones are, on average, nonsignificant (Table 4). Relative and absolute best values agree within their errors (Table 4); this implies the correctness of modern distance scales, at least on average. Combining all results obtained since 1974 yields a current "best value" of $R_0 = 7.9 \pm 0.2$ kpc.

Notice that Eisenhauer et al.'s (2003) estimate alone, $R_0 = 7.94 \pm 0.42$ kpc, does not solve entirely the problem of R_0 because of, at least, an insufficient accuracy—it does not reject values of $R_0 = 7.5$ or 8.5 kpc preferred by some authors (see N03). Besides, Eisenhauer et al. (2003) predict slow future improvements in the accuracy of this estimate. Thus to gain a further progress in the R_0 problem, more efforts in *different* lines of investigation are required.

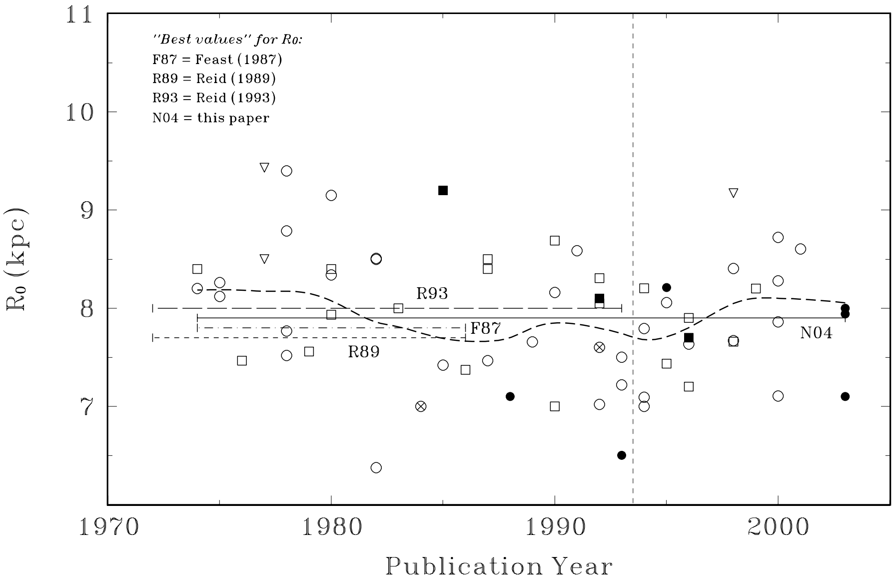

Figure 1. Rescaled estimates of R_0 (see text) versus publication year since 1974. The dashed curve is a smoothed dependence. Solid symbols, open ones, and crosses ($\times$) in symbols are R_0 estimates derived respectively from absolute, relative, and theoretical RDs by spatial (circles), kinematic (boxes), and non-phase methods (triangles).

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